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DANIAE, FENNIAE, NORVEGIAE ET SUECIAE

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VOL. 36 OCTOBER 1951 FASC. 4

# ANGIOPULMOGRAPHY[1]

by

*Preben Thestrup Andersen, Ib Andersen, Helge Eltorm, Thue Poulsen, E. Glistrup,* and *Hilda Petersen*

Since FORSSMANN (4), in 1931, made the first unsuccessful attempt at angiocardiography, the procedure has become increasingly widespread and is now an important diagnostic supplement to other examinations of the thoracic organs. This paper is devoted exclusively to angiopulmography in order to elucidate the diagnostic possibilities offered by this procedure, particularly its significance in the differential diagnosis of malignant growths.

As mentioned above, FORSSMANN was the first worker to inject opaque medium into the cardiac cavities and pulmonary artery. His method was the injection of the opaque medium through a catheter introduced into an antecubital vein. In the same year EGAS MONIZ, LOPO DE CARVALHOS & ALMEIDA LIMA (8) of Lisbon succeeded in producing contrast shadows of the pulmonary vessels following injection of concentrated sodium iodide according to FORSSMANN's technique. In 1936 AMEUILLE, RONNEAUX, HINAULT, DESGREY & LEMOINE (2) published their experience of arteriography of the lungs, partly by the method of the Portuguese school, partly by their own fractionated procedure.

Their paper deals mainly with arteriography in pulmonary tuberculosis. In the diseased areas they found the flow of blood reduced, delayed, or even completely arrested. They also describe the condition of the vessels in abscesses of the lung, pneumothorax, and pleurisy, but they had little experience with pulmonary carcinoma.

A few years later it was shown by CASTELLANOS, PAREIOS & GARCIA

[1] Aided by a grant from the P. Carl Petersen Fond. Submitted for publication, March 19, 1951.

From the Surgical Department A (Director: Professor P. MORVILLE) and the Roentgen Department (Director: E. DE FINE LICHT), Copenhagen County Hospital, Gentofte, Denmark.

(3) that the same contrast filling of the right heart and pulmonary vessels was obtainable by injecting the opaque medium into a peripheral vein.

ROBB & STEINBERG (10, 11), in 1938, reviewed the previous results and worked out a method applicable for angiocardiography. In order to visualize the various parts of the heart and the great vessels as clearly as possible, they first determined the circulation time to the peripheral pulmonary vessels and the carotids, thus establishing the interval between injection and exposure in each individual case. These authors emphasize that angiocardiography is a practical diagnostic procedure, affording information about abnormalities in the heart as well as the great vessels. Like AMEUILLE and associates, they demonstrated vascular changes in the lungs in tuberculosis, bronchiectasis, enlargement of the hilar lymph nodes, and carcinoma. Owing to the great advances within thoracic surgery, the demands made on thoracic diagnosis are ever increasing. Thus, the papers on angiocardiography published within the past two or three years have reported numerous modifications and technical improvements. Most interest has been displayed in angiocardiography, whereas angiopulmography occupies but a small space in the literature. Angiocardiography has been dealt with in great detail by a number of Swedish authors, such as JÖNSSON, BRODÉN, KARNELL (6) and others. Their method is partly venous, partly arterial catheterization, and they stress that a lucid angiocardiogram visualizing deformities of the heart and the great vessels requires catheterization and fractioned injection of the opaque medium, a procedure which other workers do not consider strictly necessary. Angiopulmography has been dealt with by only a few authors. MARCY L. SUSSMANN (12) was one of the first workers to employ angiopulmography in differentiating tumours from aneurysms, and in a later paper, published in collaboration with NEUHOF and NABATOFF (9), he called attention to the significance of angiopulmography in the differentiation of tumours from other morbid conditions of the heart and lungs. It is emphasized that the procedure affords a valuable diagnostic aid, since pulmonary malignancy is always accompanied by vascular changes in the form of occlusion, compression, or an irregular course of the blood vessels. In a paper from 1949 ABBOTT, HOPKINS & LEIGH (1) discuss the value of angiopulmography on the basis of 36 cases of pulmonary and mediastinal lesions. In their opinion, angiopulmography is a diagnostic procedure of the utmost importance in cases of malignant tumours, particularly of the upper lobes, and in the differentiation of vascular from avascular deformities.

## Technique

We started by using the miniature film technique described by SUSSMANN, STEINBERG & GRISHMANN (5) in 1941. The results were dis-

appointing, an exact diagnosis being impossible on the basis of the roentgenograms despite the application of the best quality of fine-grain films and a projector and screen of the ordinary type.

*Present Technique*

Prophylaxis: In addition to the ordinary clinical examination, including roentgenograms of the lungs in two views and bronchoscopy, the angiopulmography was in all cases preceded by electrocardiography and determination of the blood urea in order to detect any severe cardiac or renal disorders which constitute an absolute contra-indication. Furthermore, the patients were given a test dose of 1 cc. of the opaque medium (allergy).

*Anæsthesia*

We used general anæsthesia because of the discomfort and severe local pain in the arm concerned.

At the outset we employed nitrous oxide-oxygen-ether anæsthesia and induced apnoea during the exposures. Later, we have adopted pentothal sodium anæsthesia and simultaneous administration of oxygen without including apnoea, since the fine details of the films proved equally satisfactory, whether the patient was breathing or not, if only the exposure time was as short as possible. Whatever the type of anæsthesia and whether or not the patient is anæsthesized, facilities must be at hand to administer oxygen and artificial respiration.

*Cassette Changer*

The cassette changer consists of a slide box, closing automatically, when the cassette is in place. Changing is manual, the new cassette releasing the stop and pushing the exposed cassette out. The film size was usually 35 × 35 cm., but smaller sizes were used occasionally for special views. The patient is supine with his chest immediately above the cassette changer. The latter allows of 8—10 exposures in the course of 10—15 seconds. All the films are in the antero-posterior view, since the apparatus is unable to take two views at the same time.

*Opaque Medium*

All the examinations were made with diodone, 70 per cent, in amounts varying from 30—100 cc. The usual dose for adults was 100 cc. Percutaneous injection, at the rate of 2—10 seconds, was performed into an antecubital vein with a large record syringe and a large bore-needle.

*Complications*

No serious complications occurred in connection with the injections. One patient exhibited marked oedema of the eyelids and generalized itching, which, however, subsided spontaneously in the course of a few hours, and at the end of 24 hours the patient was completely unaffected by the examination. Nearly all the patients had rather severe attacks of coughing immediately after the injection was completed. As a rule the coughing went on for 1 or 2 minutes, and the subjects showed no other ill effects.

## Writers' Material

A total of 20 angiopulmographies were performed on patients suffering from pathological pulmonary changes with one exception (congenital pulmonary stenosis). From this series we selected 12 typical angiopulmograms which will be reported below. Among the remaining 8, 6 were made with the above-mentioned miniature film technique, whereas 2 were cases of bronchial asthma with normal angiopulmograms.

*Case 1.* Male, aged 69, Case rec. 3915/49. Admitted on Dec. 18, died on Dec. 22, 1949.

For the past 6 months increasing dyspnoea on exertion, hoarseness, cough, and expectoration. For 2 or 3 months blood-tinged, but T.b.-negative sputum. Slight pain in the right chest upon coughing.

*Roentgenogram* (Nov. 28, 1949 elsewhere): On a level with the right hilum a dense, arched shadow, with sharp demarcation at the bottom, but ending upwards in diffuse blurring. The lateral view shows the infiltration mainly anteriorly.

*Bronchoscopy:* Trachea displaced to the right. Carina thin, but not movable. Right main bronchus slightly constricted, showing mucosal oedema. Complete occlusion of the right upper lobe bronchus and almost complete occlusion of the middle lobe bronchus. No visible tumour tissue. The lower lobe bronchus is slightly constricted by oedema. Left side normal apart from slight reddening and oedema of the mucous membrane. Sputum positive for tumour cells.

*Angiopulmography* (Dec. 20, 1949) showed the lumen of the right subclavian vein tapering evenly towards the vena cava which also distinctly constricted on a level with the large tumour shadow in the upper part of the right hilum. The left pulmonary artery was clearly visualized in all its branchings, whereas the right one showed deficient filling compared with the left (Fig. 1).

*Operation:* Explorative thoracotomy: A tumour in the right upper lobe bronchus with extensive invasion of the superior mediastinum around the bronchus. Invasion of the superior vena cava which appears to be completely ensheathed by tumour tissue. After this finding was made, the wound closed. The patient died on the following day, showing signs of pulmonary embolism.

*Autopsy* showed a whitish, firm tumour arising from the main bronchus to the right upper lobe. The bronchial wall was perforated, and the paratracheal lymph nodes in-

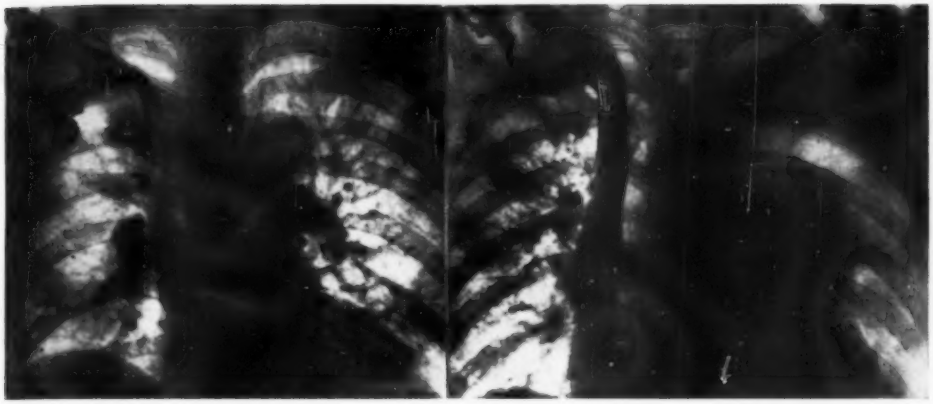

Fig. 1. Case 1. Tumour above the right hilum. The right vena cava constricted on the tumour level.

Fig. 2. Case 2. Tumour in the left hilum. Poor filling of the vessels in the left lung due to compression of the pulmonary artery on that side.

filtrated and encased by tumour tissue. Invasion of tumour tissue into the vena cava as far as the intima. Two small emboli in the pulmonary artery.

*Micr. exam.:* Solid, bronchogenic prickle-cell carcinoma.

*Conclusion: In this instance, angiopulmography showed constriction of the superior vena cava by tumour tissues, so that the tumour must be considered inoperable. In other words, angiopulmography indicated inoperability, confirmed by operation.*

*Case 2.* Male, aged 60. Case rec. 1474/50. Admitted on Apr. 24—May 4, 1950.

For a few months cough and on one occasion a small hæmoptysis. For the past month dyspnoea, pain in left chest and general seediness. No loss of weight.

*Roentgen examination including tomography* showed a dense shadow occupying the greater part of the left lung field. In the hilum a tumour, about the size of a closed fist, and at the bifurcation of the left main bronchus marked constriction of the bronchial lumen.

*Bronchoscopy* revealed a tumour in the left main bronchus. Displacement of trachea to the right.

*Angiopulmography* (Apr. 27, 1950): Marked right displacement of the superior vena cava and the other mediastinal organs. Owing to the presence of a large tumour in the left hilum and a large effusion in the left pleural cavity, the left heart was not properly visualized. Distinct visualization of the right pulmonary artery and the vessels in the right lung, but poor filling of the vessels in the left lung (Fig. 2).

*Conclusion: The patient exhibited a large tumour in the left hilum. Angiopulmography showed compression of the pulmonary artery, and the case must therefore be deemed inoperable.*

*Case 3.* Female, aged 38. Case rec. 1349/50. Admitted Apr. 14—25, 1950.

Five years prior to admission radical mastectomy including removal of axillary lymph nodes (cancer of right breast). During the 4 months preceding admission increasing

Fig. 3. Case 3. Occlusion of the superior vena cava and contrast filling of the internal jugular vein.

Fig. 4. Case 4. After partial resection of the superior vena cava a collateral circulation is seen.

swelling of the face, neck, and right arm with a tendency to cyanosis and a sensation of pressure in the throat on a level with the jugular notch.

*Clinical findings:* Swelling of the neck and the skin of the face with obliteration of the features and slight cyanosis. No hoarseness, stridor, or Horner's syndrome. No enlargement of cervical lymph nodes. No local recurrence on the right chest.

*Roentgen examination* showed a soft part shadow, about 10 × 10 cm., in the superior mediastinum somewhat to the right. Neither displacement nor compression of the trachea.

*Angiopulmography* (Apr. 22, 1950) showed filling of the arm veins as fas as their junction with the great vessels of the neck. Occlusion of the superior vena cava. The contrast medium is held up at a characteristic tumour stop and runs into the internal jugular vein (Fig. 3).

*Conclusion: In accordance with the clinical picture, angiopulmography showed an inoperable mediastinal tumour (nodal metastases from breast cancer) with total occlusion of the superior vena cava and congestion in the deep veins of the neck.*

The patient was referred for roentgen therapy.

*Case 4.* Male, aged 57. Case rec. 3907/49. Admitted Nov. 21—Dec. 22, 1949.

For 6 months prior to admission he had been suffering from a prolonged cold accompanied by cough. In the course of a tuberculosis case-finding survey at his place of work he exhibited an infiltration in the right upper lobe.

Ambulatory bronchoscopy (in July 1949) showed nothing abnormal.

A smear from the right upper lobe bronchus: No tumour cells.

The patient refused operation and failed to comply with the request to submit to continued roentgen control. When he presented himself 4 months later, the shadow in the right upper lobe had increased.

*Bronchoscopy* showed complete occlusion of the right upper lobe bronchus, and the patient was immediately admitted for operation.

On Nov. 28, 1949 he underwent right-sided pneumonectomy and resection of the superior vena cava. The operation revealed a tumour of the upper lobe with invasion of the mediastinum anterior to the bronchus and the superior vena cava. After the mediastinum had been dissected from the tumour tissue, an infiltration remained in the wall of the superior vena cava. Because of a suspicion of neoplastic tissue, oval resection of the infiltrated area was performed. The result was a constriction of the superior vena cava so that it could hardly admit a little finger.

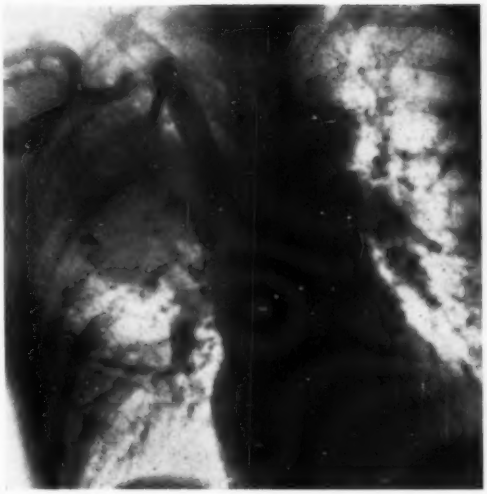

Fig. 5. Case 5. Increased vascularization around the tumour which has a poor vascular pattern.

*Micr. exam.* showed solid bronchiogenic carcinoma. Extension to lymph nodes. Invasion of vena cava (involving only the outer and middle coats, whereas the inner coat was intact).

Postoperative course uneventful.

*Angiopulmography* (on Dec. 19, 1949) three weeks after the operation showed the following changes in the venous return to the heart. From a normal innominate vein the hemiazygos vein fills as far as the diaphragm, whereas the superior vena cava is markedly constricted. Owing to the limited flow of blood containing opaque medium, it was difficult to assess the various parts of the heart. The vessels of the left lung are normal (Fig. 4).

*Conclusion: In this case postoperative angiopulmography showed the changes resulting from partial resection of the superior vena cava with extension of the collateral circulation.*

*Case 5.* Female, aged 51. Case rec. 4000/50. Admitted Nov. 27, died on Dec. 13 1950.

Four months prior to admission a cold which left pain in the right chest and greyish sputum in the morning. Slight loss of weight. No fatigue.

*Roentgen examination* showed a dense shadow, almost as large as a closed fist, posteriorly in the right upper lobe with rather smooth and regular contours on the tomograms. Some calcification of the mass in the right hilar region.

*Bronchography* showed deficient filling of the dorsal and pectoral upper lobe branches.

The nature of the tumour cannot be decided with certainty (dermoid cyst? tuberculoma?).

*Bronchoscopy:* No signs of tumour.

Sputum negative for tumour cells and tubercle bacilli.

*Angiopulmography* (Dec. 4, 1950) showed a suggestion of increased vascular pattern around the tumour and a slightly less marked vascular pattern in the tumour (Fig. 5).

Right-sided pneumonectomy on Dec. 6, 1950: Large, firm tumour occupying almost the entire upper lobe. Frozen section showed carcinoma. The tumour was firmly adherent posteriorly, where it had to be detached partly extrapleurally. Appeared to arise from the posterior branches of the apical bronchus, but involved also the posterior bronchus.

*Micr. exam.* showed solid and adenomatous carcinoma. No carcinomatous structures in the lymph nodes.

After the operation, the patient was seedy and devoid of hope. She was unable to expectorate, and despite some relief by repeated bronchoscopies and tracheal aspirations, she went downhill and expired on the 9th postoperative day.

*Autopsy* showed nothing of interest and failed to explain the cause of death.

*Conclusion: In this case angiopulmography showed the vascular changes in and round the tumour.*

*Case 6.* Male, aged 37. Case rec. 3056/50. Admitted Sept. 3—26, 1950.

During the past 3 years routine roentgenograms at a Tuberculosis Centre had shown a growing infiltration in the right lung. The patient had been in good health and exhibited no symptoms.

*Roentgen examination* of the lungs showed a right-sided nodular, extremely dense shadow, the size of an orange, on a level with the middle lobe, below and in front of the hilum. Elevation of the diaphragm, but no displacement of the mediastinum. Both costophrenic angles unaffected.

*Bronchoscopy:* No abnormality.

Tumour cells in the sputum.

*Angiopulmography* (Sept. 5, 1950) showed a normal pattern of the great vessels to the heart. Distinct vascular pattern in the lungs and neither increased nor decreased vascular pattern in or around the infiltration in the right lung.

*Operation:* Right-sided pneumonectomy on Sept. 6, 1950. The middle lobe proved to be transformed into a nodular, irregular neoplastic mass. The tumour arose from the peripheral part of the upper branch of the middle lobe.

*Micr. exam.:* Bronchogenic adenocarcinoma.

Postoperative course uneventful.

*Conclusion: In this case of a peripheral tumour in the middle lobe, angiopulmography ailed to support the diagnosis.*

*Case 7.* Male, aged 63. Case rec. 2/51. Admitted on Nov. 27, 1950.

During the past 20 years »smoker's cough» and some expectoration morning and night, no recent exacerbation. Otherwise in good health.

In the course of a case-finding survey 4 years previously an infiltration was detected in the right lung. Since then annual control films had shown an even increase in its size.

Gastric washing and sputum T.b.-negative.

*Roentgen examination* showed a smooth-edged, sharply demarcated mass without translucent or calcified areas (tomography) posteriorly in the right lower lobe. *Bronchography* showed a doubtful filling defect of the posterior basal lower lobe branch. At the same time there is a shadow, almost as large as a walnut, with regular and sharp contours between the left border of the heart and the vertebral column. The appearance of this shadow is extremely suggestive of a metastatic deposit, so that it must be presumed that either both tumours are metastases or that the tumour in the left lung is a metastasis from that of the right one.

Digital palpation of the rectum: Nothing abnormal.

Palpation of thyroid gland: Nothing abnormal.

*Bronchoscopy* showed no signs of a tumour. Sputum negative for tumour cells and tubercle bacilli.

*Angiopulmography* (Dec. 12, 1950): No pathological changes, particularly no changes in the course of the blood vessels around the tumour in the right lung.

On Dec. 15, 1950 the right lower and middle lobes were removed. There was a tumour, nearly as large as a closed fist, posteriorly in the lower lobe. In view of the presence of a small round tumour in the opposite lung, the intervention was confined to lobectomy not involving dissection of the mediastinum after involvement of the soft, anthracotic hilar lymph nodes had been ruled out by examination of frozen sections.

*Micr. exam.* revealed bronchogenic adenocarcinoma. No carcinomatous structures in the lymph nodes.

The postoperative course was uneventful. Lobectomy on the left side is to be carried out later.

*Conclusion: A case of peripheral carcinoma in the lower lobe without angiopulmographic changes.*

*Case 8.* Female, aged 60. Case rec. 2089/50. Admitted May 16—June 26, 1950.

History of pneumonia 3 months prior to admission. A suspicion of tuberculosis had not been confirmed. Constant fatigue accompanied by cough and pain in the right chest. On one occasion blood-tinged sputum.

*Roentgen examination:* In the right lung a perihilar infiltration anterior to the pectoral part of the upper lobe.

*Bronchoscopy:* Right upper lobe bronchus extremely narrow showing reddening and oedema, whence bloody sputum appears to issue. Mucosa easily vulnerable at this site. No signs of tumour.

Sputum negative for tumour cells and T.b.

*Angiopulmography* (May 22, 1950) showed no changes.

Blood tests normal.

Resection of the right upper lobe on May 24, 1950: Infiltration in the pectoral part of the right upper lobe. It was impossible to ascertain its nature at the time of operation. Frozen sections of a lymph node showed unspecific inflammation.

*The microscopic appearances* might suggest Boeck's sarcoid. Later, we received the reply to culture of the sputum which proved T.b.-positive. Transferred to a tuberculosis hospital.

*Conclusion: No angiopulmographic changes in a long-standing case of tuberculous infiltration affecting the upper lobe.*

*Case 9.* Male, aged 24. Case rec. 2195/50. Admitted June 18—July 6, 1950.

Admitted to the Copenhagen County Hospital, Medical Department from March 5—27, 1950 because of pyloric gastritis. For the past 2 months the patient had been complaining of pressure pain in the back and chest, palpitation, and air hunger. Neither cough nor expectoration.

*Roentgen examination* of the lungs showed a left-sided sharply demarcated, round shadow, about 2 × 2 cm., below and in front of the hilum, presumably in the upper lobe. Costo-phrenic angle unaffected. Sputum negative for T.b.

*Angiopulmography:* Nothing abnormal.

On June 24, 1950 resection of the left upper lobe. A well-defined, firm tumour was found at the base of the lingula. Otherwise, the lung was normal. No enlargement of

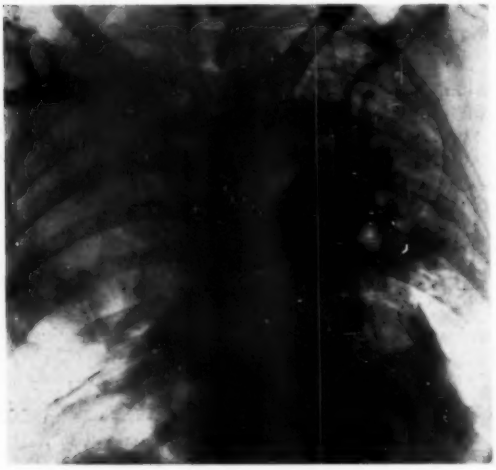

Fig. 6. Case 10. Compression of the right subclavian vein and probably of the right pulmonary artery through a not vascularized space-occupying lesion in the upper part on the right side.

hilar lymph nodes. Frozen section suggested a tuberculoma. The tumour and the distal part of the lingula were then removed by wedge-shaped excision.

Postoperative course uneventful. The patient is being followed up.

*Micr. exam.:* Tuberculoma.

*Conclusion: In a case of tuberculoma, angiopulmography afforded no diagnostic aid.*

*Case 10.* Male, aged 74. Case rec. 3760/50. Admitted Oct. 4, died on Nov. 20, 1950.

Fifteen years previously »water in the right lung», removed by puncture. Six years previously left-sided pneumonia: hospitalized, complete recovery. For past $2^1/_2$ months a mild cough and slight expectoration. Loss of weight and fatigue.

*Roentgen examination* showed a massive shadow over the upper part of the right lung field with a sharp downward convex border the lowest point of which reaches down to the ninth rib in the posterior axillary line. Plaque-shaped, pleural calcifications, calcified patches in the hilum (Infiltration of right lung? Abscess? Tumour?).

*Bronchoscopy:* Right upper lobe bronchus displaces downward. Large quantities of purulent secretion from the middle and lower lobe and smaller amounts from the upper lobe. No signs of bronchial lesion (Cyst? Extrabronchial tumour?).

Sputum negative for tumour cells and T.b.

*Angiopulmography* (Oct. 15, 1950) showed abundant filling of the right axillary vein. Pronounced constriction of the right subclavian vein immediately before its junction with the innominate vein and the superior vena cava. Right heart distinctly visualized, and there is a distinct pattern of the pulmonary artery and its branchings in the left lung. It is difficult to see the right pulmonary artery, presumably because of compression and displacement due to the large mass in the upper half of the right chest. The branches of the pulmonary artery in the left lung are extremely distinct, slightly dilated, presumably because nearly all the blood flows through the left lung and only a small proportion through the right. Rapid filling of the left heart and aorta, which appear normal. No blood vessels in the dense area of the right lung field (Fig. 6).

On Oct. 18, 1950 pleurotomy after resection of the ribs: Below a thick layer of pleura, a large cavity filled with pus. Its wall was partly calcified. Several dermoid-like masses in the pus. The cyst was not removed because of its large size and the patient's poor general health.

*Micr. exam.:* Partly calcified cystic tissue with sequelae of hæmorrhage.

After the operation ample expectoration and secretion through the inserted drain. Deteriorated and died one month after the operation.

*Autopsy:* Right lung only half the size of the left. Almost circular abscess cavity, 12 cm. in diameter and filled with pus. No abnormality of the great vessels.

*Conclusion: In this case angiopulmography showed a process occupying a good deal of the upper part of the right chest. The process was practically without vascularization, at least from the pulmonary artery. Operation showed a dermoid cyst.*

Fig. 7. Case 11. The tumour on the left side is not connected with the great vessels.

*Case 11.* Female, aged 32. Case rec. 1593/50. Admitted Apr. 15—May 14, 1950.

A routine examination at a Tuberculosis Centre showed a mediastinal tumour. The patient did not exhibit any symptoms, and clinical examination failed to show anything abnormal.

Roentgen examination of the lungs showed a roundish soft-part shadow, about 5 × 5 cm. in the superior mediastinum, projecting somewhat to the left. Slight displacement of the trachea to the right, but no compression. Fluoroscopy showed no pulsation of the tumour.

Angiopulmography (Apr. 25, 1950) showed normal filling of the superior vena cava. The opaque medium could be followed through the heart. Pulmonary artery distinct on both sides and satisfactory filling of all its branches in both lungs. No abnormal vascularization in or around the tumour in the left hilum.

Angiopulmography showed that the tumour was not connected with the great vessels. (Fig. 7.)

Operation revealed the tumour beneath the mediastinal pleura immediately over the heart and close to the arch of the aorta. It was made up of a solid, irregular and nodular part, as large as a goose's egg, and a posterior cystic part. It was well-defined, easy to remove, and did not invade the lung.

*Micr. exam.:* Typical Hodgkin's disease.

The patient received postoperative roentgen irradiation.

*Conclusion: Angiopulmography showed a roundish, mediastinal tumour not involving the great vessels.*

## Discussion

In the course of our angiopulmographic studies we have worked out a very simple technique which offers good diagnostic possibilities. In our experience the miniature film method is connected with too great technical difficulties and requires a too expensive apparatus to be applicable in routine examinations. Our present technique may be used in cases of pulmonary changes and of manifest defects in the great ves-

sels. On the other hand, we do not consider it sufficient to visualize minor defects in the heart and great vessels in which case it is absolutely necessary to be able to make films in two views at the same time as also emphasized by Swedish authors (JÖNSSON, BRODÉN, KARNELL and others). Moreover, it is no doubt useful to be able to perform venous or arterial catheterization with fractionated injection of the opaque medium. Without a doubt, this technique will come in useful in angiopulmography, and we intend to adopt it in our future studies.

Like ROBB & STEINBERG and ABBOTT, HOPKINS & LEIGH, we found that central tumours of the upper lobes result in displacement, compression, or occlusion of the pulmonary artery and, in cases of increased expansion, changes in the superior vena cava in the form of compression or invasion of the vessel. Complete or partial occlusion of the pulmonary vessels manifests itself in the form of reduced filling on the affected side, whereas the vessels on the unaffected side show accumulation of the opaque medium. In two instances, angiopulmography was the only diagnostic procedure which demonstrated inoperability, showing a characteristic tumour stop and invasion of the superior vena cava. Owing to the intimate relation to the superior vena cava, tumours of the right upper lobe are the most grateful objects for this examination, but by a suitable technique it ought to be possible to visualize aortic defects resulting from invasion on the left side. In cases of peripheral tumours, it is considerably more difficult to interpret the angiopulmographic appearances; in one instance, however, we observed peripheral vascular changes with reduced flow through the tumour and increased vascularization in its peripheral areas. Unlike KEIL, SCHISSEL & DES MOINES (7) who maintain that they are able to differentiate between malignancies and pneumonia in the process of resolution, we feel that the differentiation between benign and malignant peripheral infiltration on the basis of the vascularization is an extremely problematic matter. It must, however, be established that no vascularization is seen in the infiltrations representing cysts or tuberculomas. In this connection, films in more than one projection or stereoscopic films will no doubt prove valuable. Angiopulmography has failed to afford any diagnostic aid in tuberculosis and bronchial asthma. In our only case of angiocardiography, the diagnosis of valvular pulmonary stenosis was confirmed.

## SUMMARY

A simple method of angiopulmography is described and the diagnostic possibilities offered by this procedure are discussed. This diagnostic procedure affords help in deciding the inoperability of certain pulmonary and mediastinal tumours, their nature and localization. The writers review the literature and report 11 cases of their own.

## ZUSAMMENFASSUNG

Es wird eine einfache Methode der Angiopulmographie beschrieben und die diagnostischen Möglichkeiten besprochen, die dieses Verfahren bietet. Diese diagnostische Untersuchungsart bedeutet eine Hilfe bei der Entscheidung der Inoperabilität gewisser pulmonaler und mediastinaler Tumoren, ihrer Natur und Lage. Die Verfasser besprechen die Literatur und geben Bericht über 11 eigene Fälle.

## RÉSUMÉ

Description d'un procédé simple d'angiopulmographie et discussion des possibilités de diagnostic offertes par celui-ci. Par cette méthode l'on peut définir les cas qui se refusent à l'intervention chirurgicale, qu'il s'agisse de tumeurs pulmonaires ou médiastinales. Leur localisation et leur nature peuvent être précisées. Les auteurs résument la littérature à se sujet et présentent 11 cas nouveaux.


## REFERENCES


1. Abbott, O. A., Hopkins, W., Leigh, T. F.: The rôle of angiocardiography and venography in mediastinal and paramediastinal lesions. J. Thoracic Surg. 18 (1949), 869.
2. Ameuille, P., Ronneaux, V., Desgrey, and Lemoine, J. M.: Remarques sur quelques cas d'artériographie pulmonaire chez l'homme vivant, Bull. et mém. Soc. méd. d'hôp. de Paris 60 (1936), 729.
3. Castellanos, A., Pareios, R., and Garcia, A.: La angiocardiografia, VII Congr. assoc. Med. Pan-American, Havana 1937.
4. Forssmann, W.: Über Kontrastdarstellung der Höhlen des lebenden rechten Herzens und der Lungenschlagader, Münch. med. Wchnschr. 78 (1931), 489.
5. Grishmann, A., Sussmann, M. L., and Steinberg, M.: Multiple exposure technique in contrast visualization of the cardiac chambers and great vessels. Am. J. Roentgenol. 46 (1941), 745.
6. Jönsson, G., Hansson, B., Brodén, B. and Karnell, J.: Visualization of patent ductus arteriosus Botalli by means of thoracic aortography. Acta radiol. 30 (1948), 81.
7. Keil, P. G., Schissel, D. J. and Des Moines: The differential diagnosis of unresolved pneumonia and bronchiogenic carcinoma by pulmonary angiography. J. Thoracic Surg. 5 (1950), 62.
8. Moniz, Egas, Lopo de Carvalhos, and Almeida Lima: Angiopneumographie; Presse méd. 39 (1931), 996.
9. Neuhof, H., Sussmann, M. L. and Nabatoff, Robert A.: Angiocardiography in the differential diagnosis of pulmonary neoplasms. Surgery 18 (1949), 869.
10. Robb, G. P., and Steinberg, I.: Visualization of the chambers of the heart, pulmonary circulation and great vessels in man. Am. J. Roentgenol. 41 (1939), 1.
11. Robb, G. P., and Steinberg, I.: A practical method of visualization of the chambers of the heart, the pulmonary circulation and the great blood vessels in man. J. Clin. Investigation 17 (1938), 507.
12. Sussmann, Marcy L.: The differentiation of mediastinal tumour and aneurysm by angiocardiography. Am. J. Roentgenol. 58 (1947), 548.

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# TORUS PALATINUS AND CANCER[1]

by

*Lars Anda*

The torus palatinus was described for the first time by Fox in 1814 as an exostosis of the ossa palati. Opinions differ as to the meaning and clinical significance of this thickening of the bony palate in the median line.

HOVTON (1918) in an anthropological study, speaks of the torus as a form of hyperostosis produced by excessive use of the masticatory apparatus.

HORSLEY (1922) believes the lobular type to be an osteoma, because of the progressive, although slow-growing, nature of the lesion.

LACHMANN (1927) associated the condition with rachitic disease. The pathologic examinations, however, disclose no evidence of rickets.

K. THOMA (1944) describes the torus as a benign growth of little clinical significance.

In their book on »Human Constitution in Clinical Medicine», DRAPER, DUPERTUIS and CAUGHEY jr. (1944) report that »in two large series of breast and uterine cancer, a torus was observed in 60 per cent of the afflicted individuals. In fact in all their series of carcinoma cases, the percentage incidence is higher than in the general population (25 per cent)».

As it was considered that it would be of interest to check the correctness of this statement, a rather large number of cases have been examined at The Norwegian Radium Hospital, Oslo. From April 20 to October 20, 1948 1,490 persons were examined. The material is divided into two groups: A: One group with cancer, 1,116 cases.

B: One group without cancer, 374 persons.

In the group with cancer torus palatinus was found in 123 cases, *i. e.* 11 per cent.

[1] Submitted for publication, June 22, 1951.

In the group without cancer torus palatinus was prooved in 57 persons giving 15.2 per cent.

The distribution according to sex, age and diseases is seen from the table I and II.

**Table I**

*Group with cancer*

| | <30 years | 30—40 | 40—50 | 50—60 | 60—70 | 70—80 | At all |
|---|---|---|---|---|---|---|---|
| Disease: Cancer mammae | | | | | | | |
| Females: | | | | | | | |
| T.P.+ | | 9 | 18 | 21 | 10 | 10 | 68 |
| T.P.÷ | 5 | 35 | 106 | 100 | 79 | 51 | 377 |
| Males: | | | | | | | |
| T.P.+ | | | 1 | 2 | | | 3 |
| T.P.÷ | 2 | 5 | 6 | 5 | 10 | 5 | 33 |
| Cancer in the genitalia | | | | | | | |
| Females: | | | | | | | |
| T.P.+ | 1 | 3 | 1 | 2 | 1 | | 8 |
| T.P.÷ | 3 | 9 | 17 | 35 | 20 | 4 | 88 |
| Ca. in other regions | | | | | | | |
| Females: | | | | | | | |
| T.P.+ | | 1 | 1 | 6 | 6 | 12 | 26 |
| T.P.÷ | 4 | 5 | 20 | 36 | 44 | 62 | 171 |
| Males: | | | | | | | |
| T.P.+ | | | | 4 | 10 | 4 | 18 |
| T.P.÷ | 2 | 14 | 28 | 70 | 89 | 121 | 324 |

**Table II**

*Group without cancer*

| | <30 years | 30—40 | 40—50 | 50—60 | 60—70 | 70—80 | At all |
|---|---|---|---|---|---|---|---|
| Females: | | | | | | | |
| T.P.+ | 7 | 19 | 9 | 9 | 4 | | 48 |
| T.P.÷ | 43 | 33 | 36 | 35 | 22 | 17 | 186 |
| Males: | | | | | | | |
| T.P.+ | 4 | | 3 | | 1 | 1 | 9 |
| T.P.÷ | 27 | 16 | 17 | 24 | 16 | 22 | 132 |

## Conclusion

Investigations show definitely that torus palatinus does not occur particularly frequently in cases with cancer. In this material torus palatinus occurs in 11 per cent in the group with cancer and in 15.2 per cent in the group without cancer.

## SUMMARY

It has been claimed that torus palatinus occurs relatively frequently in patients with cancer mammae and cancer uteri. In the material of the present study torus palatinus occurs in 11 per cent in the group with cancer (1,116 cases) and in 15.2 per cent in the group without cancer (374 persons).

## ZUSAMMENFASSUNG

Es ist behauptet worden, dass Torus palatinus verhältnismässig häufig bei Kranken mit Mamma- und Uterus-Carcinom vorkommt. Bei dem Material der vorliegenden Arbeit findet sich Torus palatinus bei der Gruppe mit Carcinom (1,116 Fälle) in 11 % und bei der Gruppe ohne Carcinom (374 Personen) in 15.2 % der Fälle.

## RÉSUMÉ

Il a été proclamé que le torus palatinus serait relativement fréquent chez les malades atteints du cancer du sein ou de la matrice. Dans l'ensemble de la présente étude on retrouve le torus chez 11 % des sujets cancéreux (1,116 cas) et chez 15.2 % des sujets non cancéreux (374 personnes).

## REFERENCES

Draper, G., Dupertuis, C. W. and Caughey, J. L. Jr: Human Constitution in Clinical Medicine. Paul Hoeber, New York, 1944.

Schreiner, K.: Zur Osteologie der Lappen. Aschehoug. Oslo, 1935.

Thoma, K. H.: Oral Pathology. C. V. Mossby, C. P., St. Louis, 1944.

Hovton, Horsley and Lachmann quoted by Thoma.

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# CAUSES OF DRYING MARKS ON RADIOGRAPHS AND THEIR PREVENTION[1]

by

*Ove Mattsson*

If the dried photographic picture is to conserve in every detail the blackening produced by development, *perfect drying* is more vital than generally realized. Only correct drying of the wet film with its swollen gelatine will make each particle in the gelatine return practically to the position it occupied before it was wet, and thereby make the photographic image as true as possible. Drying is best performed without special heating at room temperature and with ample circulation of relatively dry air.[2] Unfortunately heating arrangements will have to be used to reduce the time of drying, thereby increasing the danger of unfavourable effects on the picture. CLERC stresses the fact that, when the temperature of the wet swollen gelatine approaches the melting point, the gelatine will soften and may permit a rearrangement of the silver grains producing a change in density. This is caused particularly by lengthy drying, for example when the humidity is high. It may occur without any actual melting of the gelatine. Such retarded drying usually produces an increase in density. Variations of about 25 % have thus been observed after drying under various conditions with densities that were equal before drying (WHITE 1932). The variations may occur in one identical film and produce unexpected effects. These changes due to irregular drying will have to be taken in account in high precision sensitometrical measurements. According to ROIG and THOUVENIN locally retarded drying may produce *variations in the density* of the image up to 0.4.[3] According to the circumstances the variations in density

[1] Submitted for publication, April 28, 1951.

[2] Corresponds to DIN 4512 (EDER).

[3] The density (D), as will be known, is represented by the common logarithm of the opacity (O), which is the inversion of the transmittance (T). If $T = 1/10$, D will be $= 1$. $D = 2$ corresponds to $T = 1/100$. These facts were dealt with at greater length in the author's paper, Acta Radiologica, XXXV (1951), 179.

will be more or less local and may be of great consequence for the correct interpretation of *radiographs*. If the same change affects both layers of the radiographic film in corresponding spots, the variations in density will of course show even higher values than those quoted above which refer to ordinary photographic films with only one emulsion layer.

The temperature of the air is not of exclusive importance for the production of these changes. A very important factor is the humidity: a high degree of humidity in the drying cabinet will increase the risk of irregular blackening; it increases the time of drying and also prevents the temperature from being kept down by retarded evaporation which is always accompanied by a considerable absorption of heat.

Fig. 1. Diagram of the migration of silver particles in a water spot. (From C. H. K. MEES: The theory of the photographic process, 1939.)

The most frequent cause of local variations in density is when *water-drops* remain on the surface of the gelatine during the drying. It may also happen that drops are splashed on to its surface after drying. These »drying marks» are familiar from regular photography, but they are of the greatest importance in the field of roentgen diagnostics where they may be the cause of incorrect interpretation. A certain dissolution of the swollen gelatine, accompanied by a corresponding change of the silver image, may occur in these drops as a result of protracted drying. MACK and MARTIN point out that even at a moderate temperature the gelatine will disappear into the water. The temperature limit, according to these authors, is usually about 35° C (95° F), but no temperature above 25° C (68° F) can be considered completely safe. In the course of drying, the drops will dry first along the edges of the wet region and cause the silver particles to be dragged from the centre toward the edge (CLERC). This phenomenon, however, is connected according to MEES with what is known as *reticulation*, a modification — occurring in certain unfavourable conditions of drying — in the position of the silver particles owing to tension, so that the particles aggregate in a special manner. The migration of silver in the drying edge of a water spot is shown in Fig. 1. Observations made by FREUNDLICH (1922) during the study of suspended particles moving in an electric field are very interesting. He found that particles will migrate through gelatine jelly almost as easily as through

Fig. 2. Drying marks simulating calcifications in the soft tissues at the shoulder joint.

Fig. 3. A drying mark (light spot) on a urograph.

water. Apparently the solid particles in the swollen gelatine have a high degree of mobility, especially at increased temperatures, and relatively small forces may produce deformation of the image. Gravity also seems to be of some importance, and it is not uncommon that a concentration of silver occurs in the lowest region of wet spots.

The appearance of the changes occurring in the manner described may vary a great deal. Increased or reduced densities may dominate, and the passage of drops over the surface may produce further variations. It is particularly on radiographs of the urinary system, of the skeleton and of the soft tissues that these drying marks may cause mistakes in interpretation. Some typical »film faults» of this nature observed in the Roentgen Diagnostic Department of Karolinska Sjukhuset will be described below.

The reduced density will sometimes dominate, mostly on fairly dense surfaces, and the defect will appear as a fairly clear spot. The dark edges are sometimes barely perceptible on account of the dark surroundings; on the radiograph the spot may look like a small calculus. Fig. 2 shows a detail of a radiograph of the shoulder region of a patient suspected to have a peritendinitis calcificans. The changes believed to be calcifications in typical position were shown to be drying marks. This type of change may be considered as the basic type of drying marks. A similar drying mark is illustrated in the urograph in Fig. 3. Fig. 4 a shows a detail of a plain view of the abdomen of a patient suspected to have a

Fig. 4 a. Fig. 4 b.

Fig. 4 a and b. Details from two radiographs of the abdomen. Both show a ureteral calculus. On the left the calculus is very difficult to recognize because of numerous drying spots. It is indicated by an arrow. The radiograph on the right is correctly dried and shows no drying marks.

ureteral stone. The picture shows a number of such small spots, some of them rather like small calculi. Indeed among them there is a concrement (indicated by an arrow). Fig. 4 b shows the calculus next day, when it was confirmed by urography; this radiograph shows no water spots.

If the drop of water has *moved* during the drying, stripes will be visible; the drop has then left a wet streak behind. An example is shown in Fig. 5. These streaks are fairly easy to recognize. Sometimes there is a transport of silver grains and a dark spot will appear at the end of the streak (Fig. 6). If the streak runs obliquely, however, the silver particles may sometimes accumulate as a more dense and, in thinner pictures, very marked edge along the lower limit of the wet streak. This change is very insidious, having for example been confused with fractures in skull radiographs. Fig. 7 a shows a specimen of this type. Fig. 7 b is a control picture and Fig. 7 c outlines its origin. Two similar cases with fracture-like drying marks are demonstrated in Figs. 8 and 9.

Fig. 5. Drying marks in the form of streaks.

Fig. 6. Drying mark in the form of a thin streak with a dark spot.

A more homogeneous distribution of the silver along a drying streak will occur if the streak comes from a very dense and silver-rich region and as it were, carries the silver over to a thinner region. Fig. 10 typifies such a case. The straight 'dense' lines within skeletal parts are sometimes suspected to be fractures. In the case shown in Fig. 10 the phenomenon was unique in a collection of pictures dried simultaneously, and ordinary melting of the gelatine was out of question.

A diffuse increase in density caused by general microscopic regrouping of the silver grains as described in the introduction is sometimes more local. The denser areas are unsharp, often in the form of blurred streaks corresponding to long remaining wet areas. The impression is that the silver-rich and fairly thick roentgen emulsions promote these changes. Fig. 11 shows an example. These changes will rarely present any danger of mistake. If drops from other films have been splashed on the surface of an already practically dry film denser streaks with sharp limits may be caused. Fig. 12 shows some streaks of this kind on a radiograph of a stomach.

All changes of this kind are most easily discovered by inspection of the two emulsion layers of the radiograph and by studying the light reflexes from the emulsion surfaces, according to the principle previously

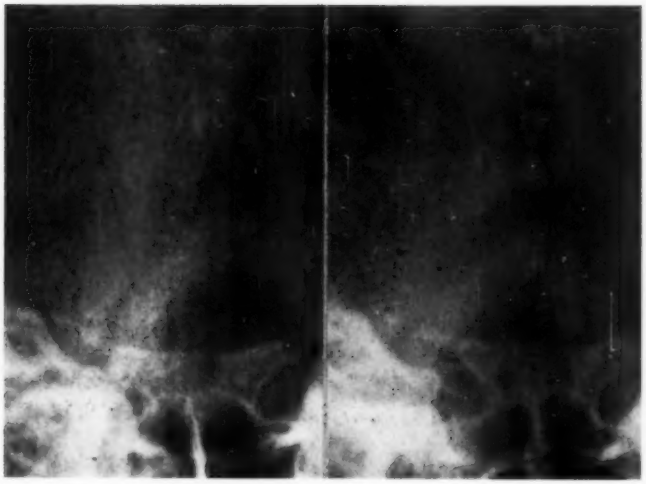

Fig. 7 a. Fig. 7 b. Fig. 7 c.

Fig. 7 a. Drying mark (dark line) simulating a fracture in the occipital region of a skull.
Fig. 7 b. A control next day showed normal conditions.
Fig. 7 c. A simple illustration of the origin of the dark line. A drop has moved obliquely downwards. Silver particles have aggregated at the lower edge because of gravity.

described by the author in Acta Radiologica (1951). When viewing the light reflexes in front light from a small lamp, the affected surface of the radiograph in Fig. 5 has the appearance shown in Fig. 13. In this way these defects are easily discovered in nearly all cases, in the same way as all other one-sided changes in the radiograph. It should be remarked that the changes will sometimes occur on both sides, which according to STEVENS (1946) is connected with the fact that a drop located on one side may also delay drying of the opposite side, probably through localized cooling of the film base resulting from the evaporation of the water stain on the back. The appearance of the gelatine observed during the inspection of the surface in this way is of another character than the normal layer, sometimes being more dull and rough and sometimes more glossy. In certain isolated cases the changes may be very difficult to detect when the surface is inspected. A magnifier will then be a great help. The spots often have an intense sharpness which never characterizes the details of the radiograph.

Inspections of films chosen at random from the last 8—9 years show that drying marks have occurred now and then during the whole period, though more frequently at certain times, probably on account of the

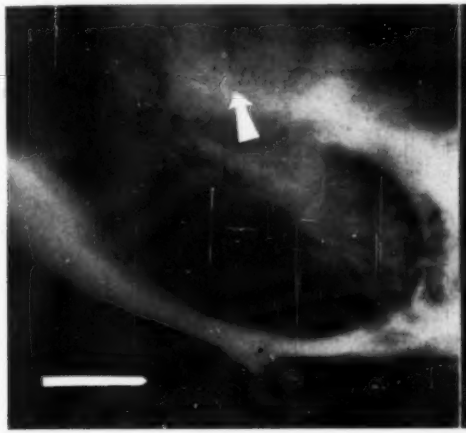

Fig. 8. A fracture-like drying mark in the parietal region. During drying gravity has worked in the direction of the thin arrow.

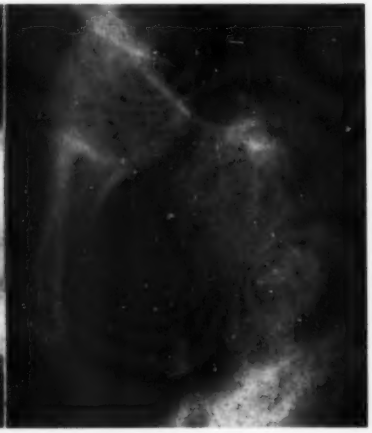

Fig. 9. Detail of an axial view of a skull with a drying mark not unlike a fracture.

atmospheric humidity. Similar observations were made at the Serafimerlasarettet, Stockholm (LINDBOM). Typically enough, no marks were found during a certain period in a department where the drying apparatus had broken down and the heating installation did not give its full output. Though it may not be possible to verify statistically any increase in the frequence of drying marks, the impression remains that they have become more frequent possibly as a consequence of the increased volume of work in the departments or of a change of the grades of gelatine used in the emulsions. The sensitivity in this respect may perhaps also vary with the origin of the film.

It is a peculiar fact that these drying marks seem to be produced in the drying cabinets under conditions which the makers of both film and film driers consider to give complete safety in this respect. Repeated inspection has shown the cabinets to be in perfect condition, and the temperatures have not exceeded the 35° C (95° F) which, according to experiments, is quoted as a maximum by the manufacturers. The temperature was read on the dry thermometer. Due to evaporation, the temperature of the film surface will be lower.

According to CRABTREE and MATTHEWS (1924) the swelling of gelatine is one of the factors affecting the nature of drying marks. The chemical treatment of the emulsion is thus of some importance. In tropical conditions hardeners are added to many baths to reduce the swelling tendencies of the gelatine and increase its resistance. Chrome alum is often

Fig. 10. Drying mark on a radiograph of a heel.

Fig. 11. Drying mark of a diffuse unsharp character.

used as an addition to the fixing bath, and a preliminary soaking in formaline solution is also carried out. In these conditions drying is possible at considerably higher temperatures, and with reduced danger of drying marks at lower temperatures. On the other hand there is reason for suspecting that modern developers, which contain a high percentage of alkali, caustic soda and so on, produce such marked swelling and softening of the gelatine that they promote drying marks. This might be the explanation of the supposed increase in frequency of these defects in recent years.

CRABTREE and RUSSEL (1944) note that the *rate of drying* is determined by the quantity of excess water remaining on the film surfaces. »If only a single spot of water is present on the film surfaces during drying, this may increase the time of drying by a factor of two or three times.» It is therefore desirable to remove excess water as completely as possible from the film surfaces.

The principal cause of these drying marks is the presence of water drops on the surface. It is intimately related with the *surface tension* of the fluid. Even when the most perfect apparatus is used, it is not possible to produce uniform drying. Certain regions become dry and, as a result of surface tension, the water left on the others is accumulated on smaller and smaller spots and finally forms drops which either remain stationary or begin to move by their own weight and leave a wet streak behind. To these are added the drops which fall from higher films in

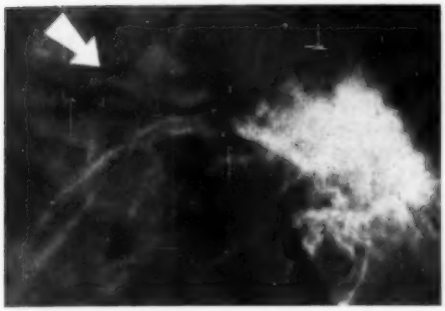

Fig. 12. Drying marks on a radiograph of a stomach.

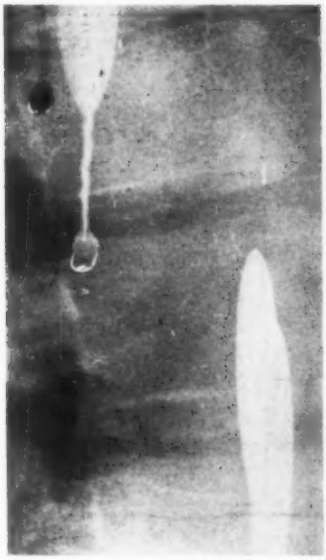

Fig. 13. A photograph of the *light-reflexes* of the layer surface, containing drying marks of the radiograph illustrated in Fig. 5. The marks are easy to distinguish when observed in this manner.

the course of drying. As the drops, through surface tension, form meniscuses or practically hemispheres on the film surface, the evaporation surface becomes very small compared with the amount of fluid involved. The absorption of heat through evaporation is therefore quite small; heat is conducted from areas already dry, and in spite of the higher temperature the drying will be slow. The causes of drying failures are thus quite evident: they are intimately connected with the surface tension problem.

A final rinse in a solution of a so-called *wetting agent* greatly contributes to complete draining (STEVENS 1946). Wetting agents reduce the surface tension and produce uniform spreading of the water over the film surface, preventing drops and making it easier for the water to »slip» off quickly.

Thus the difficulties with drying marks will be wholly eliminated and at the same time other advantages will also be secured. *The drying time will be reduced* in a considerable degree and lime spots will also be prevented.

Modern synthetic wetting agents are a group of compounds which have lately found an extraordinary number of applications in science, industry and everyday life. The surface tension reducing action already appears at low concentrations. Fig. 14 shows the correlation between concentration and surface tension. Most of the compounds reducing surface tension fall within the shaded area.

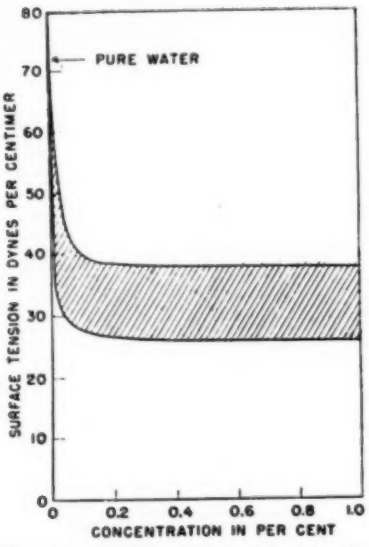


Fig. 14. Surface values for majority of surface active agents fall within shaded area on graph. (From FISCHER and GANS, quoted by A. M. SCHWARTZ and J. W. PERRY.

These actual substances belong to the surface active agents — soluble substances, the presence of which makes the surface of a solution behave quite differently from that of the pure solvent. The history of these substances dates back to World War I, when the shortage of fats and oils caused German chemists to search for soap substitutes. In the United States they were first manufactured about 1930, and chemists soon added many new ones to the list. The textile industry found them excellent for many cleansing operations, and used them as wetting agents to promote the quick and uniform absorption of dyes. Since about 1935 the technology of processes involving surface tension effects has developed rapidly. During World War II wetting agents were rapidly put to use for thousand and one purposes by the chemical industry.

At an early date doctors recommended them for use instead of soap by people who are allergic to such substances and who will get eczema on their hands from laundry soap. It was soon observed that substances of this sort have a bactericidal effect. JACOBS, HEIDELBERGER and others pointed out this fact in 1916, but general attention was not focussed on them until DOMAGK (1935) had pointed out the great possibilites of these combined cleansing and disinfecting agents. It was found later that many of the so-called cationic agents have distinct bactericidal effects.

In the course of the past decade an immense number of synthetic products with surface active properties have been in ever increasing demand for technical and scientific purposes and in everyday life. Chemically, they are of two main classes: *non-ionic and ionic*. Of these the former has non-ionizable end groups in the molecule; this class seems to be of growing importance. The ionic group, which is of current interest, is divided into *anionic* and *cationic* agents. If the long-chain portion of the molecule, which is considered responsible for the surface activity, is included in the anion, the compound is said to be anionic; cationic compounds are named correspondingly. Among the first group, aliphatic alcohol sulphonates of various kinds seem to be most common: among the latter, quaternary ammonium compounds and amines are most important. I am going to deal briefly with some well-known compounds in technical use. *Tergitol*, manufactured by the Carbide and Carbon Chemical Corp. (U. S. A.), consists of salts of higher primary or secondary alkyl sulphate. *Nekal*, made by General Dyestoff Corp. (U. S. A.), is reported to consist of sodium alkyl naphtalene sulphonate. *Igepon T*, originated in Germany by I. G. Farbenindustrie about 1930, is synthetized by combining oleic acid and methyl taurine, its formula being $C_{17}H_{33}CONC_2H_4SO_3Na$. *Invadine* (sodium alkyl phen-

$$\text{CH}_3$$

ylene sulphonate) and *Ultravon* (sulphonated complex stearyl compounds) are Swiss products made by Ciba. *Teepol*, introduced a few years ago by Shell Oil Comp., is probably a sort of sulphated olefins. These are only a few of thousands of different

compounds. They have found use in a diversity of fields, such as textile, leather, paint and ink manufacture, for washing and cosmetics and for innumerable other purposes. As already mentioned, there are a number of compounds of medical importance, used principally as non-irritating soap substitutes or highly efficient disinfectants. Of the latter type are alkyl-benzyl-dimetyl-ammonium bromide, under various names given by manufactures and CTAB (cetyl-trimethylammonium bromide). For photographic use there are special wetting agents, quite similar in their nature to the technical wetting agents mentioned above; evidently, however, the foaming tendency often found in wetting agents is reduced. Possibly so-called anti-foaming substances are added or the surface active agents themselves are chosen of such a chemical structure that they have only small tendencies to foam. A wetting agent for photographical purpose must not be influenced by salts in the water, lime or aluminium salts. Further, it is of course an absolute condition as regards photographic wetting agents that practically no substances should remain in the image after drying, *i. e.* that they are volatile. As for drying marks, their elimination has attracted attention fairly early. Among patents which concern substances to be used in connection with drying the following may be mentioned. U. S. P. 2367516, Nov. 29, 1941, on water-spot prevention in photographic film by using 0.1 % alkyl naphtalene sulphonate (MUEHLER, KUNTZ and EATONS: Eastman Kodak Co.), and U. S. P. 2490760, April 15, 1946, also on the prevention of water spots in photographic materials by the use of wetting agent of the anionic type (HENN and CRABTREE, Eastman Kodak Co.). The occurrence of drying marks is a problem of special importance in connection with processing machines for movie film, which is dried at a very accelerated rate. The surface tension of the remaining fluid is of the greatest consequence with regard to the formation of drying marks. Wetting agents are of great value, not only for drying, but also *in the developer* to prevent any traces of erratic development and eliminate an unfavourable effect of impurity and dust. It helps the developer to spread over the film surface and penetrate the emulsion uniformly. Some of the agents, however, cannot be used in a strong alkaline solution. For a fairly long time, salts of bile acids (ox bile) have been employed for photographic purposes, as well as saponin, which, however, is toxic. Most suitable seem to be the wetting agents specially developed which may be used for every phase of photographic processing. Among these may be mentioned the *Kodak* wetting agent made in U.S.A. and England, *Ilford* wetting agent made in England, the British preparation N:o *326* (Johnsons of Hendon) and *Gevatol* made by Gevaert in Belgium. There is also now a Swedish preparation named *Turmac* (Turmac AB, Lidingö). All these should be quite well adapted to their purposes. The author has learned that several commercial laboratories which also process movie film use cheaper compounds of the ordinary cleansing type, for example Teepol, for the final rinse. These compounds will certainly produce the desired reduction of the surface tension, but they also have certain drawbacks which makes it necessary with a very few exceptions not to recommend them. First of all there is a certain unfavourable tendency of foaming which may promote erratic distribution of the fluid on the film surface. Further some substances may stay behind in the emulsion and may impair the life of the film. Tests for these and other qualities may decide their suitability. Evaporation of a concentrated solution of a photographic wetting agent usually leaves an oily residue which gradually vanishes.

An evaluation of the wetting agents is easily made by studying their surface tension activity. The most striking phenomena of surface tension between liquid and gas are the capillarity, the drops, and the bubbles of gas in a liquid. There are many methods of measuring surface tension,

but the simplest seems to be the estimation of the weight of drops falling from capillaries. It was found by TATE (1864) that the drop weight is proportional to the surface tension of the liquid and the radius of the capillary from which it has fallen. This observation permits an easy comparison between the surface tension of two liquids. The ratio of their $\gamma$-values would be equal to the ratio of their drop weights when tested in a single capillary. Special instruments have been constructed for these measurements, namely sorts of drop tubes called stalagometers. The stalagometer consists of a capillary tube, the end of which is flattened. The determination is carried out at a constant temperature (20° C, 68° F), since the surface tension diminishes rapidly at higher temperatures. An important prerequisite in drop-weight measurements is that sufficient time be allowed for the formation of drops. The relation between the drop weight and the duration of the formation is illustrated in Fig. 15. When two liquids are compared in the stalagometer — the number of drops being $n_1$ and $n_2$ respectively, and their densities $d_1$ and $d_2$ — then, for a given volume, $\gamma_1/\gamma_2 = n_2 \cdot d_1 \,/\, n_1 \cdot d_2$. The weight of drops is a very complex function of the surface tension and the dimension of the capillary. LOHNSTEIN (1906) deduced a rather complicated equation,

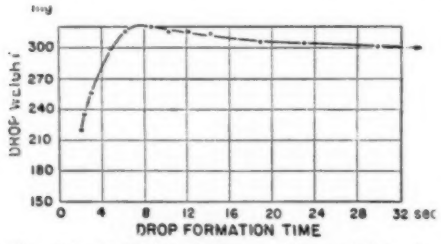


Fig. 15. Relation between the weight of a drop and the duration of its formation. (From H. NEUMANN and R. SEELIGER, Z. Physik 1939.)

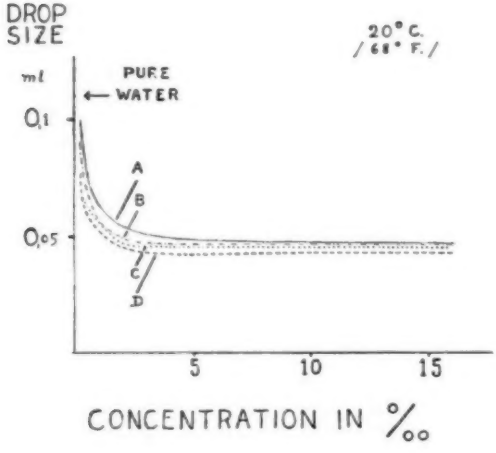


Fig. 16. The drop size (surface tension) of four wetting agents at different concentrations.

A = *Johnson 326* photographic wetting agent
B = *Teepol*, technical cleansing agent
C = *Kodak* photographic wetting agent
D = *Turmac* photographic wetting agent

Concentration refers to the dilution of the liquids.

partly with hypothetical factors. The author has compared the surface tension of solutions containing different wetting agents, three liquid preparations for photographic purpose and a technical detergent, Teepol, which is also a liquid. The results will be found in Fig. 16. The indicated concentrations refer to the dilution of test solutions. The most appropriate concentration appears to 3—5 per mille, and available instructions coincide well with the results.

The foaming capacity of surface tension-reducing substances is easily determined by shaking the solution in a measuring cylinder for a fixed time; the foam height in the cylinder is measured and presents a value of the foaming capacity. The author has made some comparative studies of this factor with the above-mentioned preparations. The solutions were all tested in the concentration giving optimal reduction of surface tension according to the above investigation. The results are presented in the table below:

A: 25 ml foam vanishing in 10 sec.
B: 50 ml foam unchanged in 5 min.
C: 25 ml foam vanishing in 10 sec.
D: 40 ml foam unchanged in 5 min.

All tests were made with 100 cc liquid. Shaking for 10 sec. It is easy to recognize the marked reduction of the foaming tendency in at least two of the photographic preparations.

According to the author's tests the amount of water in radiographic films under processing is surprisingly high. A wet film 13 × 18 ($5\,^1/_8 \times 7\,^1/_8$ inch.) with a dry weight of about 12 g (after processing) contains about 5 g water. Of this the principal amount is contained in the swollen gelatine. Only a very small part is real surface water but it is this remainder that promotes the forming of drying marks which must be prevented. The weight of the drops and other excess water which can be eliminated by wetting agents does not exceed 0.5 g. In spite of its small amount it is extremely important because of its tendency of forming drops.

One minute's treatment with the wetting agent is quite sufficient. This final rinse is easily included as a routine operation, especially if the films are suspended on the scissor-like collapsible arrangements used in the latest models of drying cabinets. The films are suspended on clips on these drying frames both during rinsing and drying. It is a very simple matter to transfer the films from the washing bath to the final rinse. Fig. 18 shows that operation.

The time of drying can be stated fairly exactly, as frequent samples are taken towards the end of the drying period to ascertain whether the films are ready. A series of measurements from two different drying cabinets on different occasions, with different degrees of humidity and

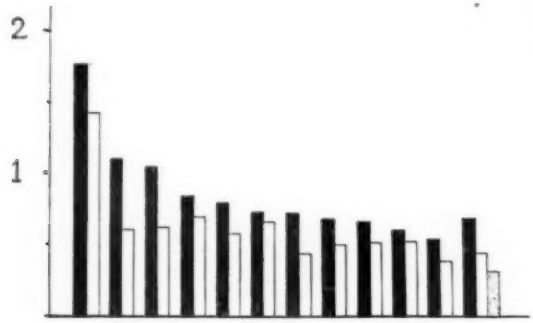


Fig. 17. Drying time under normal conditions and with final rinse in wetting agents. 12 parallel tests under different conditions. *Black areas* represent normal drying time, *white areas* with use of a wetting agent. The *shaded area* in the last test represents drying time when surplus water at the lower edge of the film has been removed with a cellulose sponge a minute or two after beginning of drying.

quantities of film, in equal conditions for the respective parallel tests, shows the values given in Fig. 17. Usually the drying time will be about 20—25 % shorter.

Even if a wetting agent is used, a narrow streak of water at the bottom of the film will always remain. If this inevitable streak be removed after a minute or so with a cellulose sponge, a cotton swab or a piece of chamois leather, the drying will be further more accelerated. Compare the last test in Fig. 17.

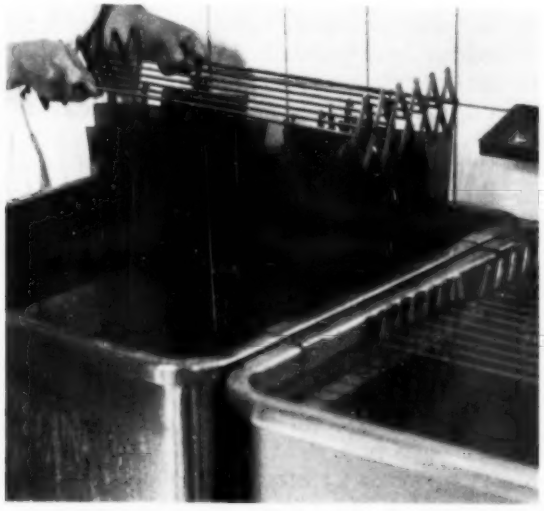

Fig. 18. A set of radiographs is transferred into the tank with the wetting agent. When not in use this is covered by a lid. To the right a washing tank.

Wetting agents are cheap in use. Very weak solutions are required, the compounds are not very expensive in themselves, and the amount of solution required is very small. For practical reasons a bath in full use should be renewed fairly frequently. The surface active substances have a tendency of being absorbed in the gelatine of the films (ROSENQUIST). The concentration of the solution will therefore gradually decrease. Small particles from the emulsion will also be detached and collected in this bath, and the solution will often be contaminated by splashes. An advantage is the economy of electric energy through reduced time of drying as the cabinets usually consume a large amount of electric power. It is in fact surprising that the prices of these compounds are on a fairly high level. A reduction in price should be quite possible.

If the proceeding outlined above were used, the personnel would only exceptionally touch the solution of the wetting agent with their hands. Even if the concentration is extremely low, there is always a possibility that the skin of some persons may be oversensitive to the substances used. As a rule these compounds prove to be very harmless and may be substituted for soap in cases of sensitive skin. According to the Swedish Public Health Institute (Statens Institut för Folkhälsan) the danger is no greater than when using soap of the same low concentration (THYRESSON). It is possible that removal of the protective skin fat will reduce resistance to other chemical agents. Indeed, the Photographic Department of the Royal Institute of Technology, Stockholm (Tekniska Högskolan), has no records up to now of cases of skin reactions caused by wetting agents (BOSTRÖM).

The purpose of the author's paper has been to focus attention on the importance of drying marks on radiographs, so that their character may always be ascertained. At the same time simple measures for their prevention have been outlined, and include the advantage of accelerated drying.[1]

[1] An interesting method of rapid drying of films has been described by MC CUTCHEON (1939). Films can be safely dried within a few minutes by the *infra-red* radiation from special carbon filament lamps. The *heat rays* from these are within a *wave length region*, which is strongly *absorbed by water*, but only slightly by the gelatine and the film base. The lamps with reflectors are placed 10—12 inches from the film surface. However, for radiographs this method has not yet reached perfection. — In places with a very humid climate, by the sea for example, drying is a particularly difficult problem. Vacuum schemes have been discussed. Drying of the circulating air in an air-conditioning apparatus will be cheaper, however.

## SUMMARY

The author describes the origin of drying marks of different types appearing on radiographic films, which sometimes disturb the proper evaluation of the radiographs. They are usually easy to discover by inspection of the two emulsion layers of the radiograph with study of the light reflexes from the emulsion surfaces. They are easily prevented by the use of a final rinse in a solution of a wetting agent before drying. This procedure also ensures a more rapid drying with usually about 20 % shorter drying time. Some tests on the properties of different wetting agents are described and directions for a practical routine are given.

## ZUSAMMENFASSUNG

Der Verfasser berichtet über das Zustandekommen von Trocknungsspuren auf Röntgenbildern und führt eine Anzahl Beispiele vor, von denen einige Anlass zur Verwechslung mit pathologischen Befunden geben können. Sie werden durch das Studium des Lichtreflexes der beiden Schichtflächen des Röntgenfilms erkannt. Die Behandlung der Filme mit einem Netzmittel verhindert ihre Entstehung und ergibt dazu noch eine Verkürzung der Trocknungszeit mit etwa 20 %. Über Versuche mit verschiedenen Netzmitteln wird Bericht gegeben, und das technische Verfahren für die Behandlung wird kurz angegeben.

## RÉSUMÉ

L'auteur relate comment les radiographes peuvent être tachées par la dessiccation et présente une série d'images types de cette espèce. Certaines de celles-ci peuvent être confondues avec des images pathologiques. On les décèle en étudiant les réflexes de la surface de chacune des deux couches de la pellicule radiologique. Le traitement de la pellicule par un agent mouillant évite l'apparition de ces taches et réduit simultanément le temps de séchage d'environ 20 %. Des expériences avec divers agents mouillants ont été tentées et elles sont décrites, leur technique est abordée.

## REFERENCES

Bikerman, J. J.: Surface chemistry for industrial research. Academic Press, New York, 1948.

Boström, A.: Moderna vätmedel i fotografiens tjänst. (Swedish.) Nord. Tidskr. Fotogr. 28 (1944), 366.

Boström, A.: Personal communication, 1951.

Clerc, L. P.: Photography. Theory and practice. Sir Isaac Pitman and Sons Ltd., London 1944.

Crabtree, J. I. and Matthews, G. E.: Markings on motion-picture film produced by drops of water, condensed water vapour, and abnormal drying conditions. Brit. J. Phot. 71 (1924), 7 and 15.

Domagk, G.: Eine neue Klasse von Desinfektionsmitteln. Deutsche Med. Wochenschr. 61 (1935), 829.

Eder, J. M.: Rezepte, Tabellen und Arbeitsvorschriften für Photographie und Reproduktionstechnik. 20.—22. Auflage. Wilhelm Knapp, Halle 1948.

FINDLAY, A.: Physical Chemistry for Students of Medicine. 2nd Ed. Longmans, Green and Co., London 1935.
FISCHER, E. K. and GANS, D. M.: quoted by SCHWARTZ and PERRY.
FREUNDLICH, H.: Kapillarchemie, 3 Aufl. Verlag von J. A. Barth, Leipzig, 1923.
GROTH, K.: Ytaktiva ämnen. (Swedish.) I. V. A. [Periodical of scientific research, The royal Swedish academy of engineering sciences, Stockholm.] 22 (1951), 9.
LINDBOM, Å.: Personal communication (1951).
MACK, J. E. and MARTIN, M. J.: The photographic process. Mc Graw-Hill, New York and London, 1939.
MC CUTCHEON, D. M.: Ultra-rapid drying. Amer. Phot. 33 (1939), 496.
MATTSSON, O.: Film-faults caused by contact between Roentgen films during the development. Acta radiol. XXXIV (1950), 166.
MATTSSON, O.: A simple masking method for the levelling of contrast in radiographic printing. Acta radiol. XXXV (1951), 179.
Medical uses of soap. A symposium. Edited by M. Fishbein. J. B. Lippincott Co., Philadelphia 1946.
MEES, C. E. K.: The theory of the photographic process. The Macmillan Comp., New York 1945.
NEBLETTE, C. B.: Photography. Its principles and practice. 4th ed. D. van Nostrand Comp., Inc. New York City 1947.
NEUMANN, H. and SEELIGER, R.: Über die Abhängigkeit der Grösse von Flüssigkeitstropfen von der Bildungsgeschwindigkeit. Zeitschr. Physik 114 (1939), 571.
OUCHTERLONY, Ö.: Ytaktiva invertsåpor, ett nytt slags desinfektionsmedel. (Swedish.) Svenska läkartidn. 45 (1948), 1341.
Photographic Abstracts. The Royal Photographic Society of Great Britain, London. (Patent Specifications.)
ROIG, R. and THOUVENIN, J.: quoted by Eder.
ROSENQVIST, H.: Personal communication, 1951.
SCHWARTZ, A. M. and PERRY, J. W.: Surface active agents. Their chemistry and technology. Interscience Publishers, Inc., New York 1945.
STEVENS, G. W. W.: Chemical aids to rapid drying. Brit. J. Phot. 93 (1946), 338 and 346.
THYRESSON, N.: Personal communication, 1951.
WHITE, D. R.: Drying conditions and photographic density. J. Soc. Mot. Pict. Eng. 19 (1932), 340.
YOUNG, C. B. F. and COONS, K. N.: Surface active agents. Theoretical aspects and applications. Chemical Publishing Co., Inc., Brooklyn N. Y. 1945.

FROM THE ROENTGEN DEPARTMENT (DIRECTOR: DR. C. SANDSTRÖM) OF ST. ERIKS HOSPITAL, STOCKHOLM, SWEDEN.

# APPARATUS FOR DIRECT CINEROENTGENOGRAPHY[1]

by

*Åke S. Gidlund*

A description is given in this paper of several types of apparatus for direct cineroentgenography, including one device for obtaining films in two planes, and one for obtaining them in single plane on a continuously moving film-strip.

Exterior views of the two-plane apparatus are shown in Figs. 1 and 2. The camera housings are mounted in a frame, and their height is readily adjustable by means of a special fitting provided with counterweights. The adjustability of the camera housings in a vertical direction facilitates the manipulation of the patient prior to taking the films. The apparatus comprises a horizontal camera housing, a vertical camera housing (marked A and B respectively in Figs. 1, 2, and 3), and a common driving mechanism (marked C in Figs. 1, 2 and 3) for the films in both planes. The horizontal camera housing is fitted with a fluorescent screen which is used for adjusting the object to be examined. The apparatus is equipped with two crossed grids (marked $R_1$ and $R_2$ in Fig. 3), one of which may be removed. The positions of the roentgen tubes for the horizontal and vertical projections are shown in Figs. 1 and 2.

The continuous film used in this apparatus in 30 cm wide (maximum size of image 30 cm $\times$ 30 cm), and the maximum length of the film 12 metres. Shorter films may, of course, be employed.

An interior view of the camera housings is given in Fig. 3. The horizontal and vertical camera housings are fundamentally similar in design and construction.

The main constructional features of the apparatus are briefly outlined in the following. A more detailed description is not possible within the scope of the present paper.

[1] Submitted for publication, May 2, 1951.

The film is rolled up and inserted in a box (see Fig. 4), which is fitted with rollers in order to reduce the mass of the film and at the same time to diminish its resistance to feeding. Firstly, the film passes over two sheaves $L_1$ and $L_2$ (see Fig. 3). The sheave $L_1$ is acted upon by a soft spring, which prevents any jerking of the film during the feeding motion. The film then passes between two intensifying screens $N_1$ and $N_2$ (see Fig. 3). The intensifying screen $N_1$ is raised and lowered by means of two solenoids $I_1$ and $I_2$ (see Fig. 3). When 30 cm of the film has been fed in, it is stopped for exposure. At the same moment, the intensifying screen $N_1$ is pressed against the other intensifying screen $N_2$, so that the film is firmly held between them, and hence kept taught. In order to prevent poor contact between the intensifying screens, they are fitted with sponge-rubber pads.

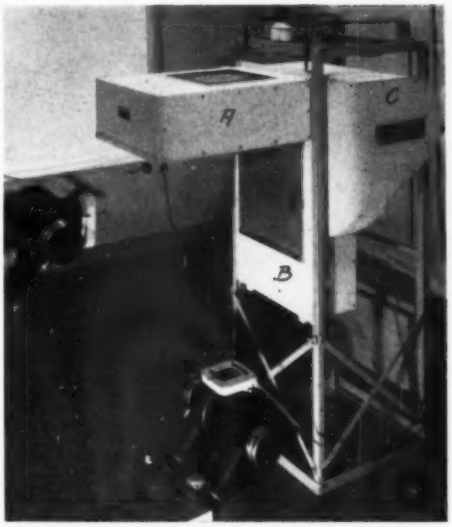


Fig. 1.

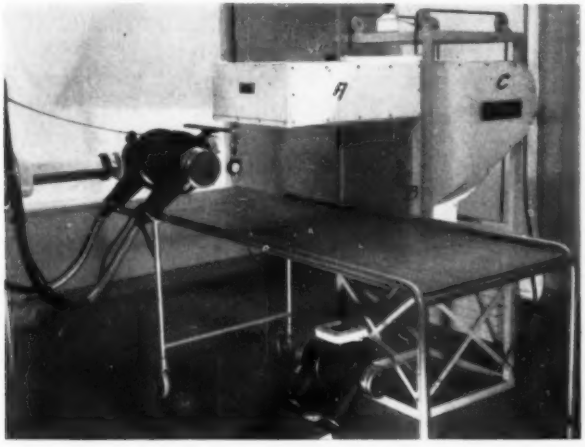


Fig. 2.

Figs. 1 and 2. Apparatus for direct cineroentgenography.

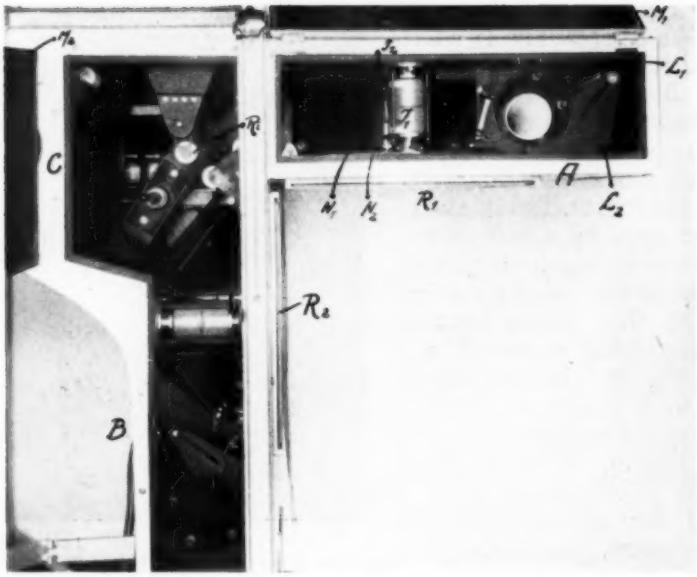


Fig. 3.

The driving mechanism is specially designed so as to ensure instantaneous arrestation of the film (see below). In addition, the apparatus is provided with special brake shoes, which gradually reduce the rate of feed of the film before it is stopped for exposure.

The films in both camera housings are fed by means of a common driving mechanism (see Fig. 3). Both films are wound around an eccentric reel Ri (see Fig. 3). During a certain defined part of a complete revolution, the reel feeds the films, but the feeding action is discontinued during the remaining part of the revolution. Consequently, the film remains at rest (for exposure) during the latter interval of time.

Both films are continuously wound on a removable drum. The rotation of this drum is synchronised with the motion of the driving mechanism. Both films are fixed on the drum by means of pegs, which can be raised by the aid of a handle at one end of the drum.

The driving mechanism is synchronised with the electric system which controls the exposure. At the same time, the driving mechanism is synchronised with an electric contactor device which controls the current impulses transmitted to the solenoids and times the current flowing through the solenoids. Hence the contactor device controls the mechanism determining the motions of the intensifying screens.

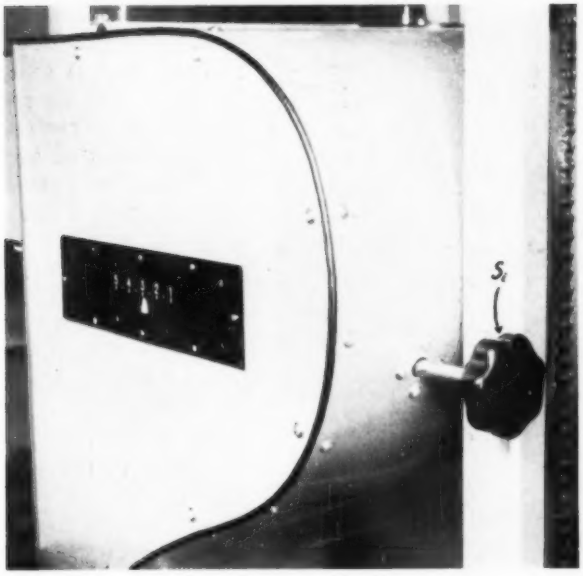


Fig. 4.

The driving mechanism is operated by a 220 V, 3/4 H.P.A.C. motor. This motor is coupled to the driving mechanism through a worm gear and a specially designed friction clutch. The clutch ensures a continuous variation in the speed of rotation of the driving mechanism, and hence in the frequency of the films. This frequency may be varied in the range from 1/2 to 5 exposures per second (in each plane). The number of films per second is varied by means of a knob (marked Si in Fig. 4), fitted in a side wall of the apparatus, and the position of which may be altered while the plant is in operation. A special contactor device is provided to ensure that the apparatus cannot be started unless both doors of the camera housings ($M_1$ and $M_2$ in Fig. 3) are closed. This is necessary in order to prevent inadvertently exposed films from being used during the examination. Another contactor device automatically stops the cameras as soon as the film is exhausted.

When the number of photographs taken per second exceeds three in number, mechanical contactors, by reason of their inertia, cannot be used for making and breaking the primary current circuit. For this reason, use is made of electronic relays.

Figs. 5 and 6 represent an apparatus for direct cineroentgenography in one plane. The design of this apparatus is based on an entirely new principle. The maximum size of the image is 25 cm $\times$ 70 cm, the film being

Fig. 5.

70 cm wide. Additionally, it may be employed for obtaining images 13 cm × 25 cm and 25 × 30 cm in size if use be made of films 13 cm and 30 cm respectively in width. Films of such width are made by Cea-Verken of Sweden, and Gevaert Film of Belgium. Films of a width of 70 cm are also manufactured by Gevaert Film. The apparatus may be utilised for films up to 20 metres in length. The interior is readily accessible through hinged doors. Grids can be inserted in the frame H (see Figs. 5 and 6).

The apparatus is loaded with film as follows:

The film, which is delivered on cardboard spools from the factory, is pushed over an easily removable metal reel, which is then fixed in place.

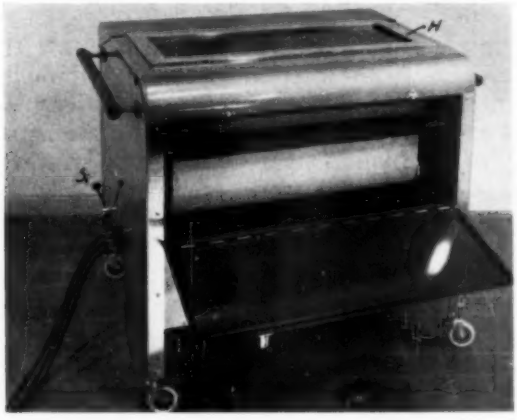


Fig. 6.

Figs. 5 and 6. Apparatus for direct cineroentgenography (one plane).

The film is then inserted between the two intensifying screens and between two rubber rollers of the driving mechanism, and is fastened by means of a simple yoke on to a drum. When the film has been exposed and wound

on the drum, the drum is removed, and the film is transferred to one of the reels forming part of a simple developing appliance.

The driving mechanism of this apparatus is very simple and absolutely reliable. The intensifying screens are raised and lowered mechanically. The number of exposures per second may be either 2 or 4. These frequencies are found to be sufficient. (The apparatus has, however, also been used for obtaining eight images per second.) The number of exposures per second may be varied by means of a lever (marked Si in Figs. 5 and 6).

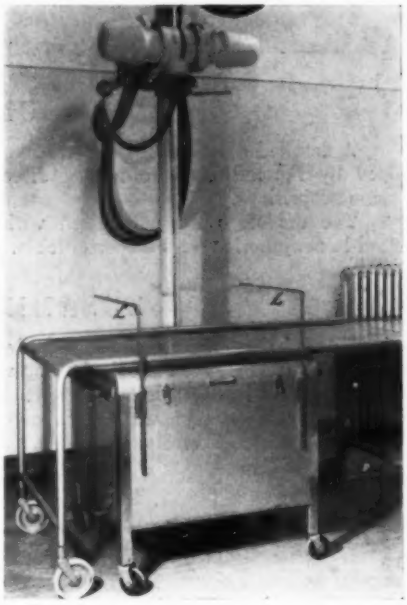

Fig. 7.

As in the apparatus described above, the exposure takes place as soon as the film is arrested and the intensifying screens are pressed against the film insetted between them. Immediately after the exposure the intensifying screens are moved apart, the film is fed in further through a given interval (25 cm in this apparatus). Then the film is stopped for a new exposure, and so forth.

The driving mechanism of the apparatus is operated by a two-speed 220 V A.C. motor. The apparatus may be actuated by means of a remote-controlled contactor device. The energisation of the roentgen tube commences at the same moment as this device comes into action. Each exposure is recorded by means of an oscillograph in order to obtain an exact timing of each film obtained. (Further particulars will be found in a further paper by the author »Angiographic circulatory studies by means of cinceroentgenography» to be published shortly.)

This apparatus should preferably be used in conjunction with a special table (see Fig. 7). The table is adapted to the height of the apparatus, and can therefore easily be pushed over the latter, to which it may be fastened. The brackets L (see Fig. 7) simplify the adjustment of the plane of the film above the patient.

I am respectfully indebted to Director A. Wenner-Gren, to the Wenner-Gren Foundation and to AB Elema-Järnh, Stockholm, for the financial help which has enabled me to carry out the present investigation.

The apparatus have been designed by the author in co-operation with AB Elema-Järnh and Ingenjörsfirma E. Swartz of Stockholm.

## SUMMARY

A detailed description is given of various types of apparatus which have been developed by the author for obtaining direct cineroentgenographic films in single and two plane projections.

The devices are synchronised with the exposure mechanism and are preferably used in conjunction with a special table.

## ZUSAMMENFASSUNG

Es wird eine ausführliche Beschreibung der verschiedenen Apparate-Typen gegeben, die von dem Verfasser zur Herstellung von direkt kineröntgenographischer Filme in der einfachen und in der 2-Ebenen-Projektion entwickelt wurden.

Die Geräte werden mit der Schalt-Vorrichtung für die Belichtung synchronisiert. Sie werden vorteilhafterweise in Verbindung mit einem speziellen Untersuchungstisch verwendet.

## RÉSUMÉ

L'auteur donne un compte rendu détaillé des divers types d'appareils développés par lui en vue d'obtenir des films cinéradiographiques dans des projections d'un ou de deux plans.

Les appareils sont synchronisés avec le mécanisme de pose et doivent de préférence être utilisés conjointement à une table spéciale.

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# ÜBER DIE VERWENDUNG SCHNELL RESORBIERBARER GASE IN DER RÖNTGENDIAGNOSTIK

von

*Werner Teschendorf*

Der Zweck eines therapeutischen Pneumothorax und eines therapeutischen Pneumoperitoneums besteht darin, längere Zeit auf die Ausdehnung der Lunge einzuwirken. Für die Röntgendiagnostik dagegen ist es angebracht, ein Gas zu verwenden, das eine kurze Resorptionszeit besitzt. Denn es kann nicht in unserer Absicht liegen, einen diagnostisch angelegten Gasraum über längere Zeit aufrecht zu erhalten.

Aus diesem Grund muss man sich eine Vorstellung über die Resorptionszeit von Gasen im menschlichen Körper machen. Man kann dabei von dem Exner'schen Gesetz ausgehen, nach welchem die Gasdiffusion durch eine Flüssigkeitsschicht proportional zu dem Absorptionskoeffizienten $a$, dividiert durch die Quadratwurzel aus der Dichte d ist:

$$\frac{a}{\sqrt{d}}.$$

Im menschlichen Körper ergeben sich aber Unterschiede, und zwar in erster Linie bei solchen Gasen, die ein Bindungsvermögen zum Hämoglobin, wie Sauerstoff und Kohlenoxyd, oder eine Fettlösligkeit wie beispielsweise Äthan aufweisen. Auch Acetylen wird fast doppelt so schnell resorbiert, als man nach der Exner'schen Zahl erwarten sollte.

Wir haben in früheren Arbeiten (8, 9) die Resorptionszeit von 600 ccm Gas in der Pleurahöhle des Hundes und die Resorptionszeit von 100 ccm verschiedener Arten von Gas in der Bauchhöhle des Kaninchens gemessen. Die Resorption in der Pleurahöhle erfolgt erheblich schneller als in der Bauchhöhle. Bei den Gasen Stickoxydul, Kohlensäure, Acetylen und Schwefelwasserstoff erfolgt die Resorption in der Brusthöhle des Hundes so schnell, dass man keinen ausgedehnten Pneumothorax anlegen kann.

[1] Bei der Red. am 2. IV. 1951 eingegangen.

Schwefelwasserstoff hat eine Narkose mit vorausgehendem Ezitationsstadium und bei genügender Menge den Exitus zur Folge. Es war auffällig zu beobachten, dass bei Infusion dieses Gases in den Pleuraspalt dasselbe ebenso rasch resorbiert wurde, als ob man es in eine Vene injizierte. Vermengte man das Gas dagegen mit Luft, so konnte eine an und für sich tödliche Menge gänzlich unwirksam werden, weil die langsame Resorptionszeit der Luft die schnelle Resorption des Schwefelwasserstoffs verhinderte.

Stickoxydul und Acetylen, welches in chemisch reiner Form des für Narkose verwandten Narcylens geprüft wurde, werden so schnell durch die Lunge ausgeatmet, dass es niemals zu einer Betäubung kommen kann, die bekanntlich auch von der Drosselung der Sauerstoffzufuhr abhängt. Die Resorptionszeiten des Gases lassen sich in folgender Tabelle wiedergeben:

| Absorptionskoeffizient a bei 0° | Dichte d bei 0° | $\frac{a}{\sqrt{d}}$ | Gas | Absorptionskoeffizient a bei 40° | Dichte d [1] bei 40° | $\frac{a\ 40°}{\sqrt{d}\ 40°}$ | Beobachtete Resorptionszeit von 100 ccm in der Bauchhöhle des Kaninchens | Beobachtete Resorptionszeit von 600 ccm in der Pleura des Hundes in Stunden |
|---|---|---|---|---|---|---|---|---|
| 0.02340 | 0.97026 | 0.0238 | Stickstoff | 0.01183 | 0.9689 | 0.018048 | 3— 4 Tage | 20—26 |
| 0.0489 | 1.1053 | 0.0466 | Sauerstoff | 0.02306 | 1.1055 | 0.02195 | 20—24 Stdn | 10—12 |
| 0.02148 | 0.069255 | 0.0816 | Wasserstoff | 0.1644 | 0.06965 | 0.063853 | 22—24 » | 7—10 |
| 0.03537 | 0.96715 | 0.03596 | Kohlenoxyd | 0.07175 | 0.9672 | 0.018048 | 16—18 » | 6— 8 |
| 0.0946 | 1.0367 | 0.09468 | Äthan | 0.02915 | 1.04939 | 0.0284 | 7— 9 » | 2— 3 |
| 1.3052 | 1.5229 | 1.0576 | Stickoxydul | 0.54435 | 1.52065 | 0.4414 | 1— $1^1/_2$ » | $^1/_6$— 1 |
| 1.7967 | 1.5198 | 1.4574 | Kohlensäure | 0.530 | 1.520 | 0.4293 | 45—90 Min. | — |
| 1.73 | 0.89829 | 1.8248 | Acetylen | 0.711 | 0.89884 | 0.8809 | 25—30 » | — |
| 4.670 | 1.17664 | 4.0293 | Schwefelwasserstoff | 1.042 | 1.1777 | 1.513 | 3— 5 » | — |

[1]) Die Dichte bei 40° wurde bezogen auf die Dichte von Luft bei 40°. Die Berechnung ergibt sich nach der Formel:

$$d\ 40° = \frac{\text{Gewicht 1 l Gas bei 0°} - \text{Gewicht 1 l desselben Gases bei 0°} \cdot \frac{40}{273}}{\text{Gewicht 1 l Luft bei 0°} - \text{Gewicht 1 l Luft bei 0°} \cdot \frac{40}{273}}$$

Überblicken wir diese Untersuchungen, so hat sich in langjähriger Auswertung dieser Arbeiten für die praktische Verwendung als schnell resorbierbares Gas am meisten das Stickoxydul bewährt. Dieses Gas ist geschmack- und geruchlos. Kohlensäure, deren Resorptionszeit noch kürzer ist, gibt auf der Zunge eine Geschmacksempfindung, die immerhin einen geringen Reiz darstellt. Obwohl Kohlensäure für das Pneumoperitoneum Verwendung gefunden hat, haben wir doch immer das Stickoxydul für geeigneter gehalten.

Fast gleichwertig mit dem Stickoxydul ist das Acetylen. Dieses war früher leicht zugänglich, weil es in vielen Operationssälen unter dem Namen Narcylen verwandt wurde. Man ist jedoch vom Narcylen abgekommen, weil Explosionsgefahr bestand und verwendet für Narkosezwecke wieder das Stickoxydul, das in Deutschland unter dem Namen Lachgas bekannt ist. Dieses ist heute daher sehr leicht zugänglich, weil es die meisten grossen Krankenanstalten in den Operationssälen vorrätig haben. Man kann dasselbe unschwer in eine geeignete Apparatur, wie sie Abb. 1 darstellt, für röntgenologische Zwecke abfüllen. Ausserdem ist Stickoxydul in kleinen Bomben von den Höchster Farbwerken zu erhalten, die einen für röntgenologische Verwendung lange ausreichenden Vorrat enthalten.

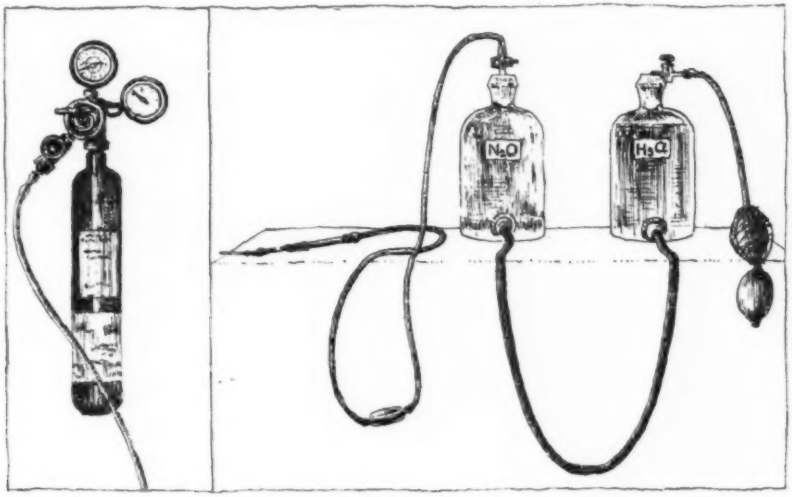


Abb. 1.

Die von uns angewandte Apparatur ist in erster Linie für das Pneumoperitoneum und für den diagnostischen Pneumothorax bestimmt. Sie kann für Gelenkfüllungen durch entsprechende Verkleinerung der Flaschen bzw. Benutzung zylindrischer Füllgeräte abgeändert werden (10). Die Flaschen tragen einen durchbohrten Gummistopfen und haben am unteren Rand eine Austrittsöffnung, durch welche die erste mit der zweiten Flasche mittels eines Gummischlauchs verbunden ist. Die durchbohrten Stopfen werden mit Glashähnen versehen. Man füllt eine der beiden Flaschen mit Wasser oder besser mit einer verdünnten Sublimatlösung und schliesst an die obere Öffnung die Zuleitung der Gasbombe an. Öffnet man jetzt den Glashahn und vorsichtig das Ventil der Bombe, so strömt

von oben her Gas in die erste Flasche ein und drückt die Sublimatlösung in die 2. Flasche herüber, deren oberer Hahn ebenfalls geöffnet ist. Man drückt die Flüssigkeit vollständig herüber und lässt zusätzlich so lange Gas einströmen, bis die Flüssigkeit, nachdem sie in die 2. Flasche herübergedrückt ist, mit einem Strom von Gasperlen durchströmt und dadurch mit Gas gesättigt ist. Das Stickoxydul hat die Eigenschaft, sich in Flüssigkeiten zu lösen. Es ist daher zweckmässig, die Flüssigkeit erst zu »sättigen».

Sobald die das Gas enthaltende Glasflasche gefüllt ist, wird der zuführende Hahn der ersten Flasche geschlossen und danach auch die obere Öffnung der 2. Flasche geschlossen. Alsdann wird der Schlauch der Gasbombe von der Öffnung der 1. Flasche entfernt und durch einen sterilisierten Schlauch ersetzt, in den ein sterilisiertes Wattefilter eingeschaltet ist. Dieser Schlauch trägt am Ende einen Metallverschluss, der in die Punktionsnadel passt. Es ist nicht notwendig, eine Flasche mit Calciumchlorid zwischenzuschalten, um das Gas zu trocknen. Als Punktionsnadel wird eine sog. Deneke'sche Nadel verwandt. Man überzeugt sich davon, dass diese Nadel vorne genügend abgestumpft ist. Das Gas strömt aus ihr durch eine seitliche Öffnung heraus.

Für die Anlegung des Pneumoperitoneums wird zunächst mit einer Francke'schen Nadel die Bauchhaut zwei Finger breit unterhalb des Bauchnabels in Körpermitte durchstossen und durch diese Öffnung die Deneke'sche Nadel eingeführt. Man spürt zweimal einen Widerstand, einmal beim Durchstossen der Haut und das zweite Mal sobald man die Faszie durchstösst. Jetzt öffnet man den oberen Hahn der 1. Flasche und kann das Gas dadurch einströmen lassen, dass man die 2. Flasche, nachdem ihr oberer Hahn geöffnet ist, höher stellt. Wir erzeugen den Druck in der 2. Flasche durch ein Gebläse, wie es unsere Abbildung zeigt. Man lässt 1—1½ Ltr. Stickoxydul einströmen.

Bei der Verwendung von Lachgas für das Pneumoperitoneum besteht der Vorteil darin, dass man keine zweite Punktion auszuführen braucht, um das Gas abzulassen. Man kann das Kleinerwerden des Gasraums beobachten. Ein kleiner Gasraum bleibt zurück, was leicht bei aufeinanderfolgenden Durchleuchtungen festzustellen ist, und offenbar durch Gegendiffusion der Blutgase bewirkt wird. Dieser Gasraum ist aber so klein, dass er keine Beschwerden hervorruft. Wir verfügen über eine 30-jährige Erfahrung in der Anlegung des Pneumoperitoneums mit Hilfe von Lachgas und der ambulanten Ausführung dieser Untersuchung. Wir benutzen lediglich die Vorsichtsmassnahme, den Kranken mit einem Auto nach Hause zu schicken. Bei einer kürzlich ausgeführten Untersuchung, die zur Feststellung der Frage diente, ob es sich nach einem Flugzeugunfall um eine Relaxatio diaphragmatica oder um eine Zwerchfellhernie handelte, wobei der intakte Bogen des hochstehenden Zwerchfells mit grosser Deutlichkeit gezeigt werden konnte, beabsichtigte der Patient nach zweistündiger Ruhe sein Auto selbst nach Hause zu fahren. Hiervon

wurde aber abgeraten. Dieses Beispiel zeigt die Geringfügigkeit des Eingriffes. Bisher ist das Pneumoperitoneum noch die sicherste Methode, die Größe von Leber und Milz, sowie die Beschaffenheit der Oberfläche dieser Organe nachzuweisen. Diese Methode ist auch nicht zu entbehren für die Darstellung der Tumoren des Pankreas, der Nebennieren usw. Auch für die Erklärung von Verwachsungbeschwerden und die Sichtbarmachung von Adhäsionssträngen bewährt sie sich sehr gut, selbst, wenn diese so stark sind, dass sie das Zustandekommen eines freien Gasraumes in der Bauchhöhle verhindern und man schon beim Einfüllen des Gases Druckerhöhungen beobachtet. Hierbei können Beschwerden entstehen, und man erkennt daran, dass die Bauchhöhle von Verwachsungen durchzogen oder in Kammern eingeteilt ist. Wegen der schnellen Resorption des Stickoxyduls lassen diese Beschwerden sehr bald nach.

Wie bereits erwähnt wurde, kommt ausser dem Stickoxydul für diagnostische Zwecke das Acetylen (Narcylen) in Betracht. Dieses Gas ist 1. brennbar und es besteht daher Explosionsmöglichkeit, 2. ist nach unserer Erfahrung die Resorptionsgeschwindigkeit in der menschlichen Bauchhöhle bereits so gross, dass der Gasraum sich schon während der Untersuchung merklich vermindert und bei längerer Dauer derselben bereits zu klein wird. Dies gilt besonders für Fälle, in denen die Röntgenbilder, wenn sie aus der Dunkelkammer kommen, aus irgend einem Grunde nicht ausreichen und wiederholt werden sollen.

Ähnlich wie Acetylen verhält sich Kohlensäure. Auch diese ist häufig für Untersuchungen von Körperhöhlen verwandt worden. Ihre Resorptionszeit steht zwischen der des Stickoxyduls und der des Acetylens. Lässt man Kohlensäure in den Mund oder in die Nase einströmen, so empfindet man einen leichten Reiz, während Stickoxydul und Acetylen völlig indifferent sind. Aus diesem Grund habe ich Kohlensäure für Füllungen menschlicher Körperhöhlen nicht verwandt. Es ist aber kein Fall bekannt geworden, in dem Kohlensäure eine Reizwirkung auf die serösen Häute des menschlichen Körpers ausgeübt hätte und auch im Tierversuch haben wir einen solchen nicht beobachtet.

Wir sind daher für röntgenologische Zwecke nicht mehr vom Stickoxydul abgegangen, nachdem seine Brauchbarkeit vor nunmehr 30 Jahren bewiesen werden konnte.

Jedoch beschränkt sich die Anwendung dieses schnell resorbierbaren Gases keineswegs auf die Bauchhöhle, bzw. das Pneumoperitoneum. Vielmehr wird das Stickoxydul mit grossem Vorteil überall dort angewandt, wo das rasche Verschwinden eines diagnostischen Gasraumes erwünscht ist.

Daher gehört auch der diagnostische Pneumothorax zu seinen Indikationen. Zwar wird auch die Luft und besonders Sauerstoff in der Brusthöhle verhältnismässig rasch resorbiert, so dass besonders bei dem

zuletzt genannten Gas gewöhnlich keine unerwünschten Nebenerscheinungen beobachtet wurden. Bestehen aber Ergüsse und raumbeengende Prozesse grösseren Umfanges, so hat auch das schnell aus der Brusthöhle verschwindende Stickoxydul seine Vorteile. Man kann seine Resorption bei in ziemlich kurzem Abstand voneinander vorgenommenen Durchleuchtungen vor dem Röntgenschirm verfolgen.

Besonders zu befürworten ist die Verwendung des Stickoxyduls für die *Pneumoradiographie des Nierenlagers.*

Diese Methode war eine Zeitlang ausser Gebrauch gekommen, wird neuerdings jedoch von vielen Autoren (1, 2, 3, 5, 6, 7), wieder für den Nachweis von Nebennierentumoren empfohlen, und sie bietet wohl den günstigsten Weg, diese Geschwülste röntgenologisch zu diagnostizieren. Gerade bei der Pneumoradiographie des Nierenlagers bestehen aber wohl die grössten Gefahrenmomente für die Anwendung einer diagnostischen Gasaufblähung, weil es hier naturgemäss viel leichter zum Eindringen des Gases in Blutgefässe kommen kann als beispielsweise beim Pneumoperitoneum. Darum sollte gerade für das Nierenlager die Aufblähung mit Stickoxydul gewählt werden, auch wenn der stärkere positive Druck, der hier der Gasfüllung entgegengesetzt wird, das Verschwinden des Gases begünstigt und daher in Wirklichkeit der Gasraum im menschlichen Körper kleiner wird, als man aus den Markierungen an der Einlaufsflasche abliest.

Auch für die Pneumopyelographie haben wir stets Stickoxydul verwandt. Bei den hier zur Verwendung kommenden verhältnismässig kleinen Gasmengen wird vielleicht praktisch der Unterschied zwischen Stickoxydul und Sauerstoff nicht bedeutend sein. Jedoch ist hier die Gefahr einer Gasembolie bei Verwendung von Stickoxydul wohl überhaupt nicht zu befürchten.

Das Gleiche gilt für die Harnblase und die Anlegung einer Perabrodilpfütze nach Kneise-Schober (4). Füllt man die Harnblase mit Luft oder Sauerstoff, so ist es zwar möglich durch den Katheter einen grossen Teil der eingeführten Gasmenge wieder herauszudrücken. Aber gerade hier springt der Vorteil der schnellen Resorption, sowie die Löslichkeit des Stickoxyduls im nachfolgenden Harn ins Auge. Man kann ohne Weiteres die für das Pneumoperitoneum angegebene Apparatur auch für diese Zwecke benutzen, wofern man nicht eine entsprechend grosse Spritze mit gut schliessendem Metallstempel anwendet.

Für gynäkologische Zwecke, insbesondere für die Tubendurchblasung ist es nicht notwendig, ein schnell resorbierbares Gas anzuwenden. Die in die Bauchhöhle gelangende Luftmenge ist so klein, daß sie keine Beschwerden hervorruft. Befürchtete man bei dieser Methode Luftembolien, so wäre die Anwendung eines im Blut löslichen Gases allerdings anzuraten.

Besondere Vorteile dagegen bieten sich bei Anwendung von Stickoxydul zur Füllung von Gelenken, sei es, dass man diese Untersuchungen mit Gas allein oder in Verbindung mit einem flüssigen Kontrastmittel ausführt. Die in unserer Abbildung wiedergegebene Apparatur modifiziert man am besten in der Weise, dass zum Abmessen des Gases ein oben mittels durchbohrten Gummistopfens verschlossener Messzylinder von 100—200 ccm Inhalt verwandt wird, an dem zur Verbindung mit dem die Flüssigkeit enthaltenden Druckgefäss eine Öffnung oberhalb seines Bodens angebracht wird (10). Hiermit lässt sich die eingeblasene Gasmenge genau dosieren. Die schnelle Resorption des Gases bedeutet entschieden eine Verkleinerung des diagnostischen Eingriffes.

Das Stickoxydul ist nicht geeignet für Myelographie und Enzephalographie. Untersuchungen, die zusammen mit Herrn Prof. RÖTTGEN in der Chirurgischen Klinik in Bonn vorgenommen wurden, ergaben, dass zwar die Einführung des Gases in den Lumbalkanal zunächst keine Beschwerden verursacht, in späteren Stunden und in der nächsten Nacht aber Schmerzerscheinungen auftraten. Dies dürfte sich dadurch erklären, dass zum Zwecke der Gas-Myelographie 20—30 ccm Liquor entnommen wurden. Infolge der schnellen Resorptionszeit dürfte keine Zeit dafür vorhanden sein, dass die entnommene Liquormenge in entsprechender Zeit neugebildet wird. Es muss sich daher ein Mangel an Liquor bemerkbar machen. Auch könnte man sich vorstellen, dass die rasche Resorption des Gases zu einem gewissen Sog führt und hierdurch eine Reizung der Meningen herbeigeführt wird.

## ZUSAMMENFASSUNG

Es wird über die Resorptionszeiten von Gasen im menschlichen Körper berichtet und für das diagnostische Pneumoperitoneum, den diagnostischen Pneumothorax sowie für Gelenkfüllungen und andere Zwecke die Verwendung von Stickoxydul ($N_2O$) empfohlen. Die schnelle Resorptionszeit dieses Gases gestattet eine weitgehendere Indikationsstellung für das Pneumoperitoneum und für die ambulante Anwendung dieser Methode. Das gleiche gilt für den diagnostischen Pneumothorax, für die Pneumoradiographie des Nierenlagers, für die Pneumozystographie und die Tubendurchblasung. — Für die Myelographie und Enzephalographie ist ein Gas, das schnell resorbiert wird, nicht geeignet.

Flüssigkeiten, die bei Körpertemperatur verdampfen, sind zur Erzeugung von Kontrasten im Röntgenbild nicht geeignet.

## SUMMARY

The different absorption times of gases in the human being are discussed. Nitrogen monoxide ($N_2O$) is recommended for radiography of the peritoneal cavity, the pleural cavity, for the filling of joints, etc. In view of the fact that this gas is rapidly absorbed its use will not only increase the indications for diagnostic pneumoperitoneum but will also widen the possibilities of employing this method of examination in ambulant patients. This also applies to radiography of the pleural cavity, pneumoradiography of

the kidneys, pneumocystography and radiography of the Fallopian tubes. It is stated that a gas which is rapidly absorbed does not lend itself to myelography and encephalography.

Liquids which evaporate at body temperature should not be employed as contrast media.

## RÉSUMÉ

L'auteur expose le temps de résorption des gaz dans le corps humain et préconise l'emploi du protoxyde d'azote ($N_2O$) dans le pneumothorax diagnostique comme pour les pneumos des articulations ou autres. La rapidité avec laquelle ce gaz se résorbe le rend spécialement intéressant dans le pneumopéritoine et pour l'emploi ambulant de cette méthode. Il en est de même pour le pneumothorax diagnostique, pour la pneumoradiographie des reins, pour la pneumocystographie et pour l'insufflation des trompes utérines. Par contre un gaz à résorption rapide n'est pas indiqué pour la myélographie ni pour l'encéphalographie.

Des liquides qui s'évaporent à la température du corps ne sont pas recommandés pour l'obtention du contraste dans les radiographies.

## LITERATUR

1) Cahill, G. F.: Air injections to demonstrate the adrenals by x-ray. J. of Urol. 34 (1935), 238.
2) Hasner, E.: Om perirenal insufflation (Schwedish). Nord. med. 15 (1942), 2701.
3) Jury, A.: Neumoporarriñón; uso de una nueva via. Prensa méd. argent. 36 (1949), 35.
4) Kneise, O. und Schober, K. L.: Die Röntgenuntersuchung der Harnorgane. G. Thieme, Leipzig, 1941.
5) Kokas, F. u. Zsebök, Z.: Röntgendarstellung der Nebenniere und der Niere durch perirenale Lufteinblasung. Fschr. Röntgenstr. 74 (1951), 218.
6) Mitchell, G. A. G.: The renal fascia. Brit. J. Surg. 37 (1950), 257.
7) Rivas, M. R.: Roentgenological Diagnosis. Generalized subserous emphysema through a single puncture. Am. J. Roentgenol. 64 (1950), 723.
8) Teschendorf, W.: Über die Resorptionszeit von Gasen in der Bauchhöhle, Arch. f. exper. Path. u. Pharmak. 92 (1922), 302.
9) Teschendorf, W.: Über die Resorptionszeit von Gasen in der Brusthöhle, Arch. f. exper. Path. u. Pharmak. 104 (1924), 352.
10) Teschendorf, W.: Zur Verwendung eines leicht resorbierbaren Gases (Stickoxydul) für die Darstellung der Gelenke und des Pneumoperitoneums. Fschr. Röntgenstr. 53 (1936), 476.

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# STEREOMICRORADIOGRAPHY[1]

by

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Quantitative microradiography (historadiography) has proved to be a valuable method of investigation in histo- and cytochemistry. In many investigations, such as microradiographic studies of the mineral distribution in bone tissue, it would be of value also to be able to localize the structures under analysis in the third dimension. This may be possible by some sort of stereoscopic microradiography. Microradiography at oblique angles would also make it possible to determine the thickness of biological samples. This communication describes the techniques for the microradiographic determination of thickness of microscopical samples and for stereomicroradiography.

## Principle

In Fig. 1, which illustrates the principle of stereomicroradiography, the sample has the thickness d, and the two points A and B are imaged with roentgen rays having oblique incidence. If the two roentgen pictures are examined at unit magnification there are two conditions that must be fulfilled for good stereoscopic vision (BERTHOLD).

1. The angle of convergence $\gamma$ must not exceed 20°.

2. The difference between the angles of convergence for the point A and B, $\delta$, must not exceed 70′.

With the denominations in Fig. 1 the requirement mentioned under 2 can be expressed (for small angles of $\delta$):

$$\sin \frac{\varphi}{2} = \frac{a - d}{d} \tan \frac{\delta}{2} \quad \ldots \ldots \ldots \ldots \quad 1$$

[1] This work was performed at Physics Department, Stanford University, California, on a Rockefeller Fellowship. I wish to thank Prof. PAUL KIRKPATRICK for placing equipment to my disposal and for his stimulating interest in this work.

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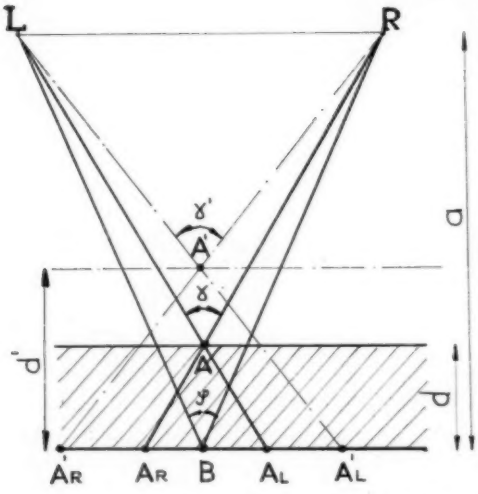



Fig. 1. Principle for stereomicroradiography.

For tilting angles less than 20° and if the allowed maximal value of $\delta$ is introduced the equation can be written

$$\varphi \leqq 1.17 \left(\frac{a}{d} - 1\right) \quad . \quad . \quad 2$$

where a is the distance between the roentgen ray source and the film and d is the thickness of the sample. If the microradiogram is magnified m times, the points $A_R$ and $A_L$ will fall at $A'_R$ and $A'_L$, respectively, while the point B has its original position. The new angle of convergence $\gamma'$ now becomes greater than $\gamma$ and therefore the tilting of the sample must be smaller. According to BERTHOLD, Eq. 2 now can be written:

$$\varphi \leqq 1.17 \frac{\left(\frac{a}{d} - 1\right)}{m} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 3$$

The tilting angle $\varphi$ is limited by the angle of convergence $\gamma'$ which cannot exceed 20°.

In Fig. 2 is shown the calculated tilting angle as a function of the

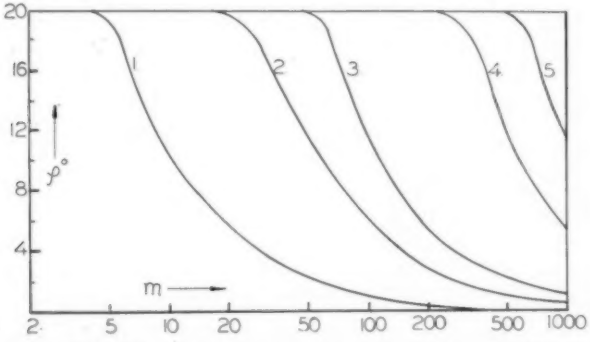



Fig. 2. The tilting angle $\varphi$ as a function of the magnification m. Curves 1 to 5 are for a : d = 100, 500, 1,000, 5,000 and 10,000, respectively.

magnification of the microradiogram for different values of $\frac{a}{d}$. Similar curves were calculated by BERTHOLD for low magnifications and relatively thick specimens. The curves presented in Fig. 2 are directly applicable to the conditions used in historadiography.

## Technique

A Machlett AEG 50 roentgen tube was used as the source of radiation. The samples, which consisted of c:a 50 $\mu$ thick ground sections of bone tissue, were mounted 5 cm from the window of the roentgen tube on a holder which could be tilted to different angles. When tilted, the axis of rotation (vertical) was lying in the back plane of the sample which was pressed against the surface of a fine-grained Lippmann emulsion. When taking microradiographs of the thin bone samples the roentgen tube was run with 10 kv and 20 ma. The exposure times varied between 2 and 20 minutes. The tilting of the sample-film, the angle $\varphi$, could be set with an accuracy of 0.05°. The microradiograms were enlarged by photomicrography.

## Results

a. *Stereomicroradiography.* Two microradiograms of a thin bone sample each tilted 8 degrees from the plane normal to the roentgen beam ($\varphi = 16°$) are shown in enlargement in Fig. 3. Viewed in a stereoscope, the spatial distribution of the osteocytes, etc., can be studied. A better three-dimensional vision is obtained if the negatives from which the copies in Fig. 3 were prepared are viewed in the stereoscope.

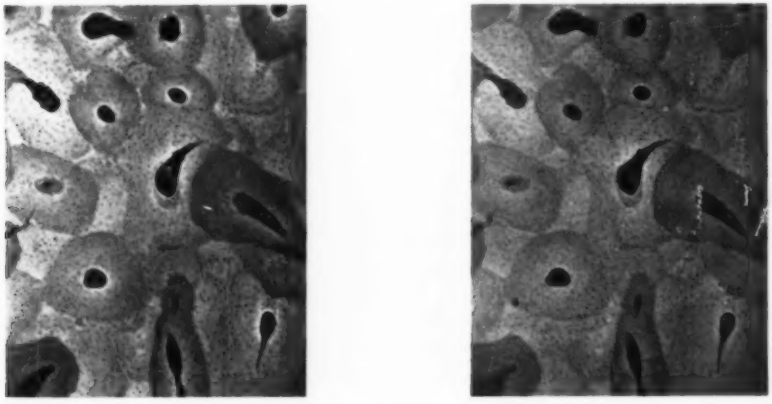
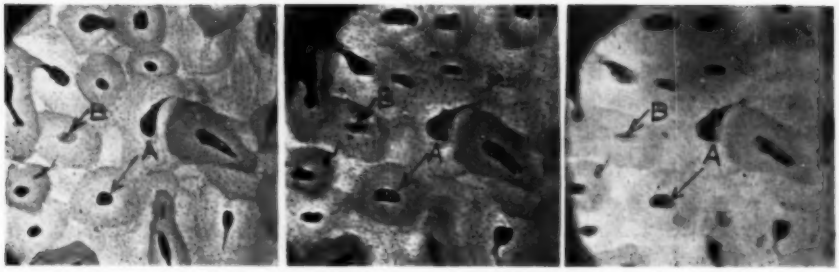
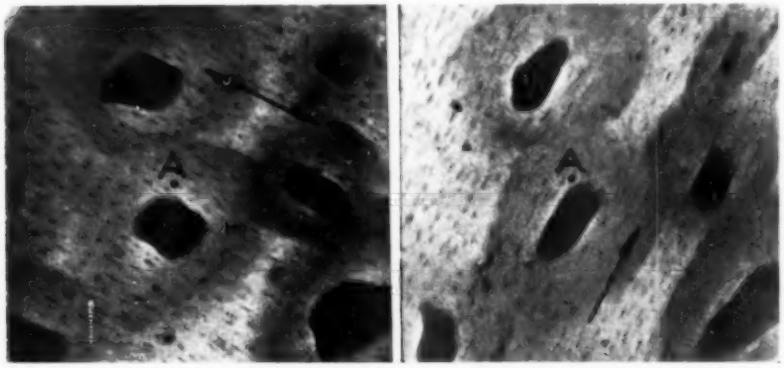


Fig. 3. Stereomicrographs of bone tissue. Magnification 45 ×.




a. b. c.

Fig. 4. Microradiograms of a bone sample. a. normal incidence of roentgen rays, b. sample-film tilted 45°, heavy exposure. c. the same as in b. but light exposure. A and B indicate identical structures. Magnification 45 ×.




a. b.

Fig. 5. Enlargements of microradiograms of bone tissue. a. the sample-film tilted 45° and b. rotated 90°. Magnification 100 ×.

b. *Determination of thickness.* If the microradiograms of the bone specimen registered with normal incidence of the roentgen rays are compared with microradiograms taken with an incidence of the rays of 45° (both directions from the beam, $\varphi = 90°$), the thickness of a structure can be calculated from each set of three microradiograms. In Fig. 4 are shown enlargements of microradiograms of the same sample as shown in Fig. 3. In Fig. 4 a the incidence of the roentgen rays is normal. In Fig. 4 b the sample and film are tilted 45° from the normal. This microradiogram is strongly exposed. The broadening of the image of the blood vessels at A and B can clearly be seen in Fig. 4 b. Fig. 4 c finally shows the shadows

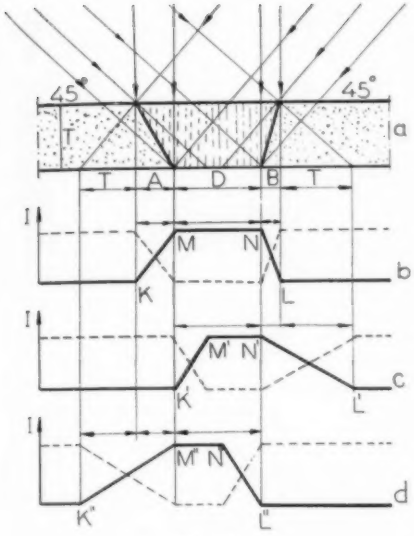



Fig. 6.

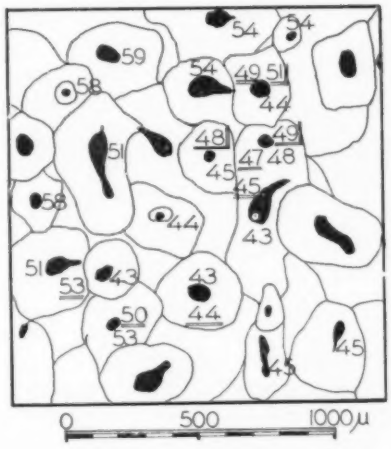



Fig. 7.

Fig. 6. Schematic drawing showing the intensity distribution of roentgen rays transmitted at different angles through a sample. a. cross section of sample. The solid curves in b, c, and d show the intensity distribution when the hatched area in a is non-absorbing (*e. g.*, a blood vessel in bone tissue). For the broken curves the hatched area is absorbing and the rest non-absorbing.

Fig. 7. Determination of thickness in a bone specimen. The black areas are the blood vessels and the lines indicate the borders of the Haversian systems. Thickness given in $\mu$.

of the edges of the blood vessels in the sample. This microradiogram had a very weak exposure.

Fig. 5 a shows a microradiogram of a sample which was tilted 45° from the normal. The sample was then rotated 90° (the axis of rotation coincident with the direction of the roentgen rays) and another microradiogram, shown in Fig. 5 b, was registered. The point under A indicates the same structure in the two cases.

Suppose a structure has the cross section shown in Fig. 6 a. The intensity distributions of the transmitted roentgen rays for 90°, +45° and −45° incidence are shown in Fig. 6 b, c, and d. If the microradiogram is strongly exposed, as is the case in Fig. 4 b, a photometer track across the image localizes the points K and L very accurately. The fine-grained emulsions have very high gamma values. If the radiograms are very weakly exposed (cf. Fig. 3 c), with soft rays giving good contrast, the points at M and N can be determined. The distance M to N which is D,

can also be measured directly in the sample by microscopic techniques. Using the three roentgen ray projections,[1] it is seen that it is possible to determine the thickness of any structure. The deduction shown in Fig. 6 can be carried through for any geometrical configuration of the sample.[2] As an example, the thickness of a ground bone specimen has been determined and is shown in Fig. 7. Each figure is determined from 3 microradiograms (+45°, 90°, and —45° incidence of roentgen rays). The underlined values were calculated from microradiograms registered when the specimen had been rotated as shown in Fig. 5. The accuracy of the method depends upon the accuracy with which the broadening of the structures can be determined. If an enlargement of 200 times of the microradiograms (45-degree incidence of roentgen rays) is used and the broadening of a structure which corresponds to the thickness can be determined with an accuracy of 0.2 mm, *i. e.*, 1$\mu$ in the original picture, the error in thickness determination will be 1$\mu$. This accuracy is good enough for samples about 50$\mu$ in thickness but must be increased for thinner samples. This can be arrived at by increasing the angle of incidence and using very soft roentgen rays securing high contrast in the sample and thereby making it possible to determine the broadening of a thin structure more accurately.

## SUMMARY

A method for stereohistoradiography is described. Using oblique incidence of roentgen rays when registering the microradiograms, the thickness of microscopic samples can be determined.

## ZUSAMMENFASSUNG

Es wird eine Methode der Stereohistoradiographie beschrieben. Durch Verwendung des schrägen Einfalls der Röntgenstrahlen während der Einstellung des Mikroradiogramms kann die Schichtdicke mikroskopischer Untersuchungsproben bestimmt werden.

## RÉSUMÉ

Une méthode de radiographie stéréohistologique est décrite. En utilisant une incidence oblique de rayons Roentgen lors de la prise du microradiogramme on peut déterminer l'épaisseur du prélèvement.

## REFERENCES

BERTHOLD, R.: Vergrösserte Röntgen-Raumbilder von Metalldünnschliffen. Metallwirtsch. 20 (1941), 694.

[1] Eventually in connection with light microscopy.

[2] For certain specimens, however, it may be necessary to tilt the sample more than 45°.

FROM PHILIPS' RESEARCH LABORATORIES, EINDHOVEN, HOLLAND

# A SYSTEMATIC METHOD WITH NEW STANDARDS TO DETERMINE THE CORRECT MAGNITUDE OF RADIOGRAPHICAL EXPOSURES[1]

by

*A. Bierman*

## 1. Introduction

In common photography the correct exposure depends on various factors, the influence of which is not always easy to estimate because of the great number of objects to be photographed and the variety of light sources available. Even with an exposure meter the deviations may be considerable. Nevertheless the average amateur generally gets acceptable results thanks to the great margin the photographic emulsion allows, together with the possibility of using different printing papers. This is not the case with radiographs and therefore generally a deviation up to a factor $1^1/_2$ from the ideal exposure value is already too much. On the other hand the number of objects is much more restricted and the roentgen ray source gives a radiation which we have well in hand. The big handicap effecting so many a failure, however, is the lack of adequate standards, without which it will not be possible to give reliable directives.

Though the lack of standards is already serious enough, even more confusion is caused by the use of wrong standards. An illustrative example is the »intensifying factor» of the screens, of which the definition is: the ratio of exposures giving the same film density with and without the use of screens. This, however, depends largely on the films used, and moreover two interpretations are possible, for the non-screen exposure can be taken on the same film as used with screens, or on a film specially intended for non-screen technique (the latter interpretation gives the real gain which the screens entail and gives a considerably smaller factor than the former).

[1] Submitted for publication, April 24, 1951.

Both interpretations are found in practice, so that the intensifying factor of a certain screen may have two values, *e. g.* 50 and 10, both of which are based upon serious measurements.

Another source of errors is the difference in results due to different curve forms of the tension and the difference of tube properties (grid effect of the cathode, inherent filter, etc.). Also the technique of processing plays a part, and so there are many possibilities to cause confusion.

Finally it may be useful to draw attention to a source of discrepancies due to an incorrect usage when mentioning the difference between magnitudes, such as film speed, screen qualities, exposures, etc. In these cases the difference is often expressed in percentages, *e. g.*: »this film is 50 % faster». Now, what does this mean? Probably »1 1/2 times as fast»; the film with which one compares is then taken as 100 %. But then »50 % slower» means a factor 2 instead of 1 1/2. And still more mysterious is: »the difference is 50 %» because then no one can tell what is exactly meant. With small differences (25 % or less) this is not so serious, but even then cumulation of wrong factors may lead to considerable errors. The only correct way is, never to use percentages but always *factors*.

The object of this article is to describe a method with which all these sources of errors can be eliminated with the aid of standards with which the magnitude of exposures will be measured. For the sake of clarity it will be necessary to introduce also some new names and symbols, so that »one language» can be spoken when exposure questions are discussed. (However, these names and symbols are only meant as suggestions.)

## 2. Standardization of Exposures

There are many factors determining which exposure is necessary in order to get a correct film density. All these factors, however, can be placed in any of three groups, and each group will be characterized by one number based upon the above mentioned standards.

### a) *The value of the exposure* (*E*)

The exposure value depends on four elements, forming together the »setting» of the roentgen apparatus:

| | | |
|---|---|---|
| The tension | *kV* | (throughout this article always the peak value is meant) |
| The tube current | *mA* | |
| The exposure time | *sec* | |
| The focus-film distance | *m* | (meters) |

Should it be possible to express the value of an exposure in *one* magnitude, following from these four components, then this would simplify

considerably the calculations in radiographical technique. The only simplification, hitherto introduced, is the use of the mAs number, which means that the resulting film density is not affected by the choice of the values of mA and sec, provided that their product is kept constant. This is not quite correct, because the reciprocity law does not hold exactly (Schwarzschild exponent), but the errors due to this fact are small enough to be neglected in practice. A further step towards our aim can be performed when we also involve the distance. The exposure must then be proportional to the square of the distance, and therefore the expression $\frac{\text{mA sec}}{\text{m}^2}$ has to be kept constant for a certain result, no matter how the composing factors are varied. Should we be able to involve also the tension in our formula, then we would have one number giving the value of the exposure when the four components are given. Now, recent investigations have proved that this is possible; it has been found that the density of a radiograph remains practically constant when varying kV and mAs in such a way that the value of the product $(\text{kV})^5 \times \text{mAs}$ is kept constant (Bierman & Boldingh).

Thus, the number characterizing the value of an exposure is given by the expression:

$$(\text{kV})^5 \times \frac{\text{mAs}}{\text{m}^2}$$

The four components can be changed without effecting the result, provided that the value of this expression remains unchanged. In order to get suitable numbers, we take as the unit of exposure that value, obtained with 100 kV, 1 mAs and 1 m. We choose the symbol »*E*» for the *value of an exposure* and will give the unit the name »*radiographical exposure unit*» with the symbol *r e u*. Hence we have:

$$\text{Exposure E} = \left(\frac{\text{kV}}{100}\right)^5 \times \frac{\text{mAs}}{\text{m}^2} \text{ r e u}$$

The correct exposure is consequently given by a certain amount of, r e u. The separate values of the four components (the setting of the apparatus) depend on the other requirements as: contrast (kV), movement blurring (sec.), admissible tube load (kV, mA and sec), focussing of the grid (m), etc. But here we will occupy ourselves exclusively with the radiographical results in terms of film density, and in this context the value of the exposure E is sufficient.[1]

[1] The exposure E is more or less comparable with a dose, but the use of this word is not advisable, because every possible confusion with the real dose, measured in r, has to be avoided.

The ease entailed by the use of E soon appears when applying this standard in practice. It is, for instance, easy to remember that a radiograph of a normal lung requires about 1 r e u, of a normal stomach about 25 r e u, etc. (with the normal films and screens, now available).

Neither the distance nor the kV or mAs need to be borne in mind. The inconvenience that the formula for E requires some computation is removed by the nomogram in fig. 3 (described in par. 3).

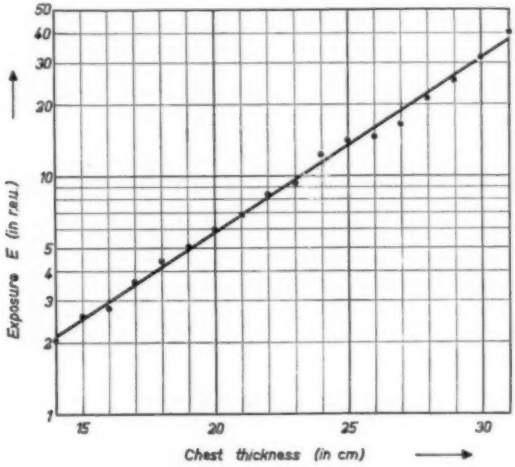



Fig. 1. Requisite exposure E with various chest thicknesses for miniature radiographs of lungs. (An increase of 4 cm in thickness requires a doubling of the exposure.)

Another example of the use of E is given in fig. 1. Here the required amount of r e u is plotted logarithmically against different chest thicknesses, giving the correct exposure when making miniature chest radiographs. The values of E are computed from data determined by Dr. G. C. E. BURGER applying to a four-valve apparatus in combination with a Philips mirror camera, Gevaert »Scopix» films and a Levy West screen. The different values lay fairly well on a straight line, which generally occurs when plotting the mAs against the thickness, the tension (and distance) remaining constant. As the different exposures have been made with different tensions as well as with different mAs, the straight line confirms the reliability of the use of E.

b) *Characterization of the radiographical outfit* ($E_a$)

The exposure necessary for a given object depends on many things, as roentgen apparatus, tube properties, film screen combination, Bucky

grid, camera for taking miniature radiographs, processing technique[1], etc., etc. All these factors, achieving a radiograph, will be taken together under the name *»radiographical outfit»* (even the person who influences the processing technique may be included).

When a certain object, say a thorax, is radiographed with different radiographical outfits, the necessary exposures will generally be different too. For instance, when taking two different film screen combinations, the ratio of the two exposures be 2. Now, practice has shown that this ratio also holds good with other objects, so that in our example the ratio of two exposures necessary for, say, a stomach, will also be 2. Though this statement must not be regarded as a physical law, this rule is accurate enough for normal practice. This means that a radiographical outfit can be characterized (as far as it concerns the requisite exposure) by taking exposures of *one* object and deciding which of them gives the best film density. Then the amount of r e u of the ideal exposure for this object forms the base from which all the exposures of other objects can be derived. So, when we choose an appropriate *standard object*, we shall be able to characterize any radiographical outfit with one number (the amount of r e u necessary for this standard object), which we will call the *specific exposure*, with the symbol $E_s$. As water is the best substitute for the human tissue with respect to radiographical properties, our standard object can best consist of water. For practical application it is desirable to choose not too big an object, so that it can be taken along from one place to another. Moreover, this gives suitable numbers for the basic exposure table (see c)).

After some investigations it has been found practical to take for the standard object a cube with an edge of 10 cm, so that it contains one kg of water. This can easily be realized by means of a coverless box of some material which, as to the absorption of roentgen rays with diagnostic wavelengths, does not differ too much from water (»Perspex», a transparent plastic of I. C. I., is used by the author). The horizontal dimensions in both directions are 10 cm *externally*, and the height is about 11 cm; marks on the side walls indicate to what height it has to be filled with water, and make it possible to avoid an oblique position. The marks must be placed so that the total thickness of water plus bottom amounts to 10 cm. In this way the phantom can be used both in vertical and in horizontal direction, and the deviation from pure water is very small, because the roentgen-rays penetrate a total thickness of 10 cm, of which only a few mm are made of a material the absorption effect of which is only slightly different from that of water.

[1] It is obvious that there is only question of correct exposures, if this technique is kept constant.

This standard object is smaller than a big diagnostical object, so that the amount of scattered rays is also smaller than with big objects. This entails that the effect of a Bucky grid is smaller with our phantom than with a big object, but as the measurements with the standard object are comparative, this difference is not serious. Only the differentiation between various grid properties will be somewhat less with our standard object than with objects which are considerably bigger. On the other hand the dependence of the grid effect on the dimensions of the object and the magnitude of the irradiated area has never been taken into account in normal practice, and this does not meet with any objection. In fact experiments have shown that the choice of the phantom dimensions does not lead to incorrect exposure values.

*We define the specific exposure $E_s$ of a radiographical outfit as the amount of radiographical exposure units necessary to cause a film density 1.0.*

In order to determine the specific exposure, different exposures (some 4 exposures with a ratio of 2 each time are generally sufficient) are taken *on one film*, and after processing and drying the different film densities are measured. As the amount of scattered rays is somewhat greater in the centre part than at the periphery, the resulting film density is maximal in the centre part. In order to obtain reliable values the density must be measured in this part of the phantom image. If no densitometer is available, the densities can be estimated fairly well by comparison with a scale of measured densities on a small piece of film; experiments have shown that the latter method is very useful and that the difference with the measured values is small enough to give reliable results (the best way of comparing two densities is to fit them close, without any margin between them). After having measured or estimated the densities, the obtained values are plotted against the corresponding exposures, and so a curve can be drawn giving the exposure value belonging to the density 1.0. It is advisable to take the exposure scale logarithmic, for then the part of the obtained line where the density 1.0 is found, will be approximately straight, which gives more accurate results. Line patterns, as caused by Bucky grids, lead to wrong density values and hence have to be avoided.

For normal films and screens, now available, and a normal roentgen apparatus the value of $E_s$ generally lies between 0.5 and 1.0 reu (without Bucky grid). The magnitude of $E_s$ is a sufficient standard for the characterization of a radiographical outfit, no matter what the values of the four components have been. But for the sake of accuracy the most reliable result is obtained when we choose for the tension an average value of those commonly used in diagnostics, so that possible deviations, due to the fact that the formula for E is not quite exact, be reduced to the smallest amount. Therefore we take *75 kV* as the tension used when determining

$E_s$. In case this tension is not obtainable with the apparatus, the tension nearest to 75 kV has to be taken (of course the computation of $E_s$ must be based on the real value used!). Possible inaccuracies of the measuring instruments are automatically taken into account by the use of $E_s$ when the relative value of the deviations is constant. Though this is not always the case, the correction involved in $E_s$ is generally sufficient.

With the aid of $E_s$ a comparison of different radiographical outfits is quickly made. For example, the difference between an equipment for full size radiographs of lungs and one for miniature radiographs gave as results $E_s = 0.70$ and $E_s = 8.3$ respectively. These two outfits were quite different in many respects, as: films, screens, camera, stationary grid (the latter two were only available in the outfit for miniature radiographs), etc. Yet the two values of $E_s$ have proved to be sufficient to derive the correct exposures with the camera installation from the exposures with the other outfit.

### c) *Characterization of the object to be radiographed* ($E/E_s$)

In the usual exposure tables an abundance of data is found, referring not only to the object to be radiographed but also to the setting of the apparatus and to the radiographical outfit (*e. g.* screens, Bucky grid). These data are far from superfluous, and useful enough for daily practice, but not sufficient to predict what exposure will be necessary in other circumstances, *e. g.* with other tensions, other film screen combinations, etc. For this purpose there is a need of a *basic exposure table*, from which the exposure data in different circumstances can be derived.

With the help of the exposure standard E it is possible to characterize each object with one number, enabling us to calculate the correct exposure with any radiographical outfit of which $E_s$ is known.

In the foregoing paragraph we mentioned the fact that the ratio of the correct exposures of different objects is independent of the properties of the radiographical outfit used, provided that the same outfit is used for all different objects. So, if we determine the exposure ratio of all the objects to, say, a normal thorax, this would be sufficient to compute all the other exposures when the correct exposure for this thorax would be known. Now, it is not advisable to refer the exposures to a »normal thorax», because the definition of the latter will give great difficulties. Therefore the best solution is to refer all exposures to a *standard object*, and it is obvious that we take for this purpose the same phantom as already utilized for the determination of $E_s$.

When a certain object requires an exposure E, then the ratio of this exposure and the specific exposure $E_s$ will be a reliable standard for the characterization of our object. We shall call this ratio, $E/E_s$, the *»relative exposure»* of a certain object.

The various relative exposures determined in this way attribute to each object only one number, namely $E/E_s$, and *the so obtained basic exposure table will hold good irrespective what technical improvements will be introduced in radiography*, because E and $E_s$ will always change with the same ratio. Even when radiographical technique will be altered in such a way that our formula for E has to be changed (*e. g.* because the fifth power is no longer correct), this will not affect the basic exposure table; in fact, the whole method described in this article will then remain applicable.

The basic exposure table being available, we compute the correct exposure E by multiplying $E/E_s$ by $E_s$. This computation can be done with the aid of the nomogram in fig. 4 (described in par. 3). It was our intention to combine this nomogram with the basic exposure table by placing the names of the objects next to the $E/E_s$ scale. But as we do not yet dispose of the correct values, this had to be omitted.

As an example a few approximate values are given here:

| *Object* | $E/E_s$ |
|---|---|
| Hand p a | 0.3 |
| Thorax p a | 1.0 |
| Knee a p | 2.5 |
| Skull p a | 15 |
| Stomach survey | 30 |
| Pregnancy | 60 |
| Pelvis lat. | 250 |

Because each object is characterized by one number it is possible to place these numbers in the corresponding parts of a diagram of the human body (frontal and lateral view). In this way the desired number is easily found.

The majority of the values of $E/E_s$ is greater than 1, because the thickness of our standard object has been chosen to be only 10 cm and thus we get suitable numbers for the basic exposure table.

### d) *Synopsis*

The value of a radiographical *exposure E* is determined by

$$E = \left(\frac{kV}{100}\right)^5 \times \frac{mAs}{m^2} \quad \text{(in reu = radiographical exposure units)}$$

A *standard object* (a water phantom with definite dimensions) is used to characterize the »radiographical outfit» with the *specific exposure* $E_s$. This is the value of E required to obtain a film density 1.0 when radiographing the standard object. The exposures required for a certain object can be computed with the aid of $E_s$ and the *relative exposure* $E/E_s$. This

is the ratio of the requisite exposure to the specific exposure, a number that can be attributed to each object once for all, and holding good for any radiographical outfit. The different values of $E/E_s$, belonging to the objects, constitute together the *basic exposure table*, from which the correct exposures are derived with the formula: $E = E/E_s \times E_s$. The basic exposure table needs no correction, irrespective of possible improvements in radiographical technique. All computations can be avoided with the help of two nomograms.

*An outline of the whole procedure is given schematically in fig. 2.*

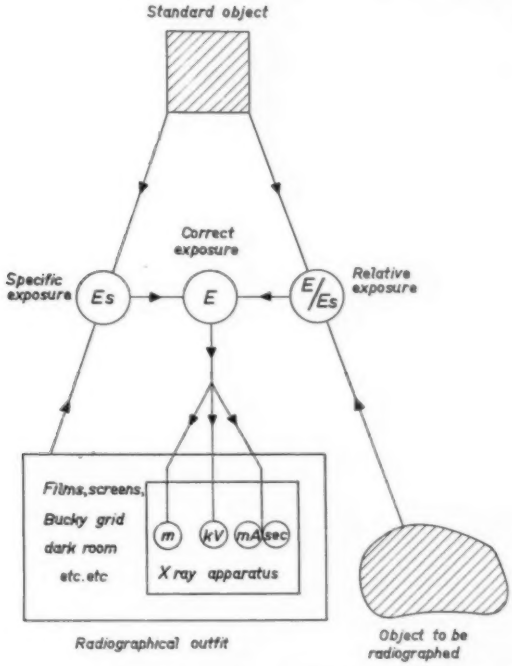



Fig. 2. Schematic outline of the procedure described in this article.

## 3. Determination of the Exposure Magnitudes with the Aid of Nomograms

Application of the method described in the foregoing paragraphs is possible without any computation when using two nomograms designed for this purpose. The nomogram of fig. 3 gives the relation between the radiographical exposure value E and the composing elements m, kV and

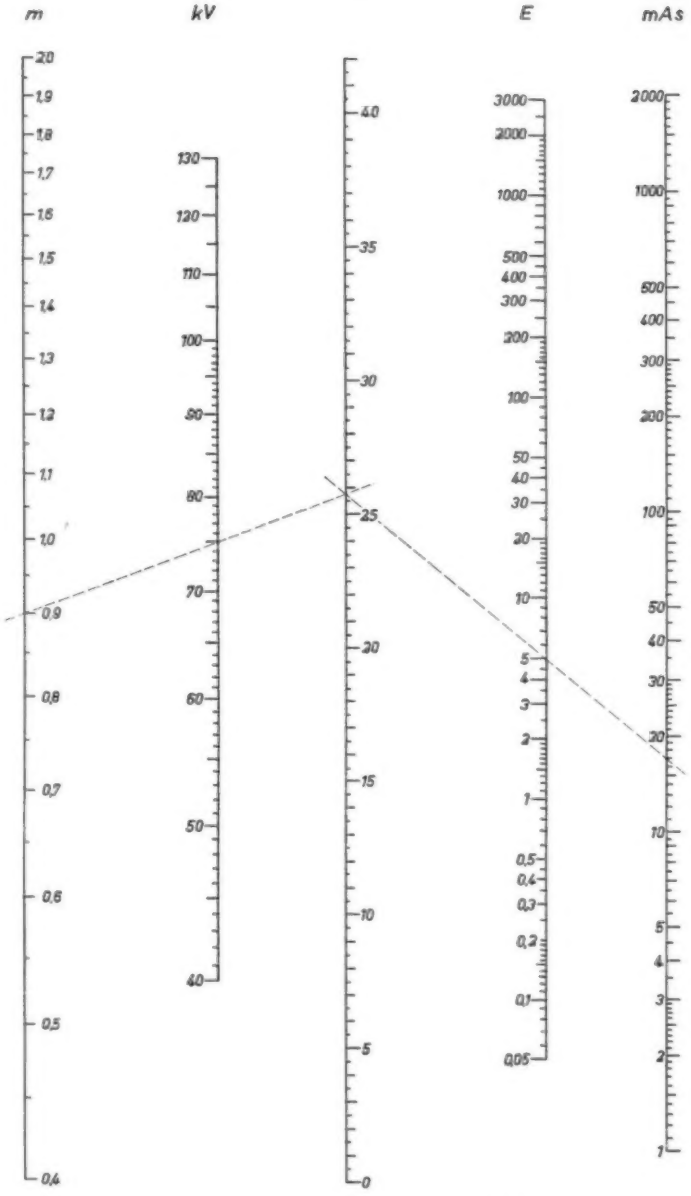



Fig. 3. Nomogram for the formula: $E = \left(\frac{kV}{100}\right)^5 \times \frac{mAs}{m^2}$.
The broken line refers to the example in par. 3.

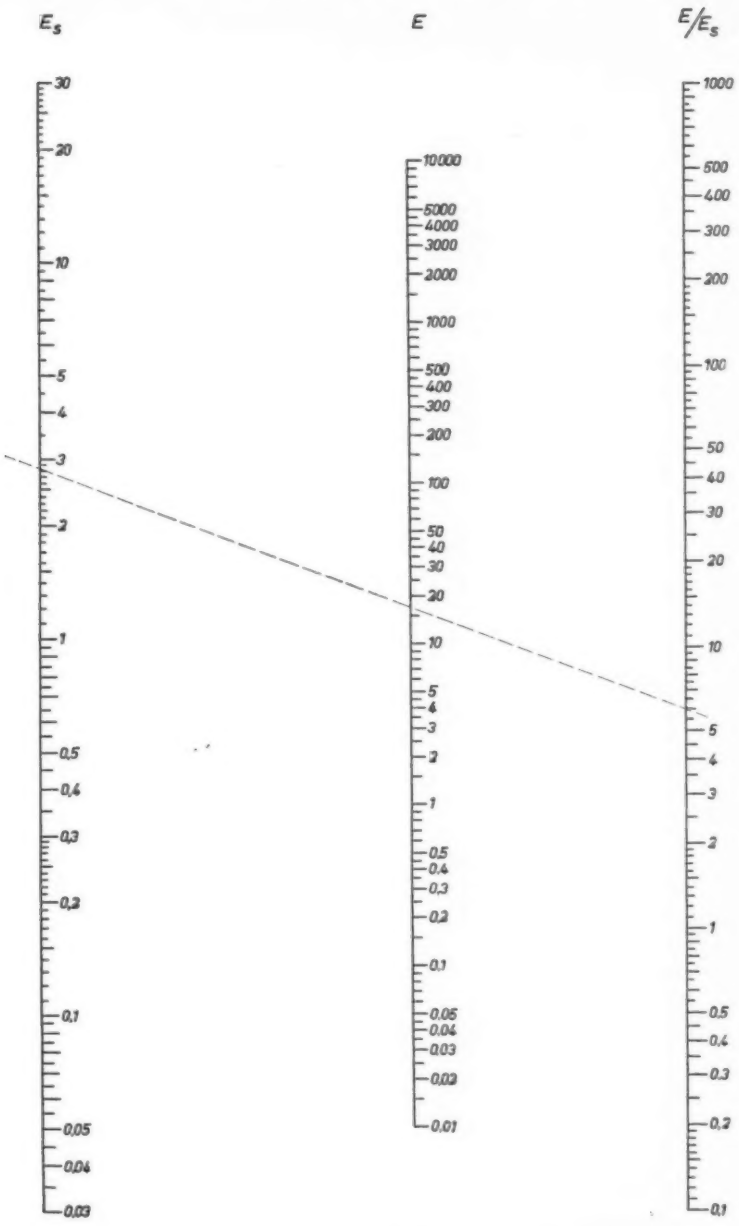



Fig. 4. Nomogram for the formula: $E = E_s \times E/E_s$.
The broken line refers to the example in par. 3.

mAs. (As the two elements mA and sec. are generally combined to mAs, E can be composed of three instead of four elements; by this the nomogram is considerably simplified.) The formula for E can be entirely ignored when this nomogram is used.

Besides the four scales for m, kV, E and mAs there is an auxiliary scale with arbitrary numbers. An example, illustrated by two broken lines, may demonstrate how the nomogram is used:

We wish to determine the number of mAs necessary to obtain an exposure $E = 5.0$ when the distance is 0.9 meter and the tension is 75 kV. We draw a straight line between the values $m = 0.9$ and $kV = 75$. From the intersection point of this line with the auxiliary scale another straight line is drawn to the value $E = 5.0$, intersecting the mAs scale at the value 17, which is the desired value. The arbitrary numbering of the auxiliary scale serves merely to retain the intersection point. (In practice the lines are not actually drawn but are best realised by a black wire.) When the three composing elements are known and E has to be determined, the procedure is analogous. In fact, the nomogram enables to find one of the four values: m, kV, E and mAs when the three others are given; two straight lines drawn from one point of the auxiliary scale, give four values belonging together according to the formula: $E = \left(\frac{kV}{100}\right)^5 \times \frac{mAs}{m^2}$.

The nomogram of fig. 4 gives the relation between the values of the exposure E, the specific exposure $E_s$ and the relative exposure $E/E_s$. Three values, belonging together according to the formula $E = E_s \times E/E_s$, are given by the intersection points of a straight line with the three scales. Example, illustrated by a broken line:

A certain object requires a relative exposure $E/E_s = 6.0$. The radiographical outfit is characterized by a specific exposure $E_s = 2.8$. The requisite exposure E for our object appears to be 17 (multiplication gives 16.8, but it is evident that 17 is accurate enough).

A third example may illustrate the use of both nomograms:

A radiographical outfit has been measured with the standard object and the result is: $E_s = 3.7$.

With this outfit we wish to make a radiograph of a skull p. a. with a tension of 80 kV and a distance of 1.0 m. In the basic exposure table let a skull p. a. be characterized with a relative exposure: $E/E_s = 15$. The nomogram of fig. 4 gives the requisite exposure value: $E = 55$. This, together with $m = 1.0$ and $kV = 80$, gives the necessary amount of mAs with the aid of the nomogram of fig. 3, namely 170 mAs.

It is possible to combine both nomograms in such a way that only one scale for E is necessary. Also, in the same nomogram, scales for mA and sec. separately can be introduced, and even the power in kilowatt and the energy in kilowattsec. can be given, together with curves giving the full load magnitudes for different tubes. Such a nomogram has

been designed and used by the author and may be useful for those accustomed to these procedures. For the sake of clarity, however, the two simple nomograms of this article seem to be more adequate.

## SUMMARY

The value of a radiographical exposure is expressed by one number in which the amount of mAs, the tension and the focal distance are involved. With the help of this exposure value and a standard object (water phantom) any radiographical outfit (apparatus, film, screens, Bucky grid, etc., etc.) is characterized with one number, the »specific exposure». The same standard object is used to characterize any radiographical object (in terms of requisite exposure) with a number called »relative exposure». The specific and the relative exposure give together the correct exposure for the given object and radiographical outfit. Two nomograms make it possible to proceed without any computation.

## ZUSAMMENFASSUNG

Der Wert einer Röntgenbelichtung wird ausgedrückt in einer einzigen Zahl, worin die Anzahl mAs, die Spannung und der Fokusabstand einbegriffen sind. Mit Hilfe dieses Belichtungswertes und eines Standardobjektes (Wasserphantom) wird jede Aufnahmeausrüstung (Apparat, Film, Verstärkungsfolien, Buckyraster, usw.) gekennzeichnet mit einer einzigen Zahl, die »spezifische Belichtung». Dasselbe Standardobjekt wird benutzt um jedes Aufnahmeobjekt zu kennzeichnen (so weit es die erforderliche Belichtung betrifft) mit einer Zahl, die »relative Belichtung» genannt wird. Die spezifische und die relative Belichtung bestimmen zusammen die richtige Belichtung für das gegebene Aufnahmeobjekt und die Aufnahmeausrüstung. Zwei Nomogramme ermöglichen es, alles ohne rechnen durchzuführen.

## RÉSUMÉ

La valeur d'une pose radiographique est donnée par un seul nombre dans lequel la quantité de mAs, la tension et la distance sont compris. A l'aide de cette valeur de pose et d'un objet standard (fantôme d'eau) chaque outillage radiographique (appareil, film, écrans, grille antidiffuseur, etc., etc.) est caractérisé avec un seul nombre, la »pose spécifique». Le même objet standard est utilisé pour caractériser chaque objet radiographique (en ce qui concerne la pose exigée) avec un nombre, appelé »pose relative». La pose spécifique et la pose relative donnent ensemble la pose correcte pour l'objet et l'outillage dont il est question. Deux nomogrammes permettent d'opérer sans aucun calcul.

## REFERENCES

BIERMAN, A. & BOLDINGH, W. HONDIUS: The relation between tension and exposure times in radiography. Acta radiol. 35 (1951), 22.

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# TREATMENT OF UTERINE CANCER WITH RADIOACTIVE COBALT ($Co^{60}$)[1]

by

*Carl-Erik Johanson, Gustaf Östling* and *R. V. Gåsström*

Cancer of the uterus is next to cancer of the breast the most common form of malignant tumour in women. During the last hundred years an appreciable number of different treatments have been developed. At the beginning surgery, giving fairly encouraging results, was the treatment of choice. But new paths were opened and better results obtained since radiation physics in the form of radium and roentgen treatment gave new opportunities about fifty years ago. Today a new era has been reached as a consequence of the progress of modern nuclear physics. Radiological literature already contains some preliminary reports on the use of radioactive cobalt and other isotopes in the treatment of cancer.

The use of radium in the treatment of tumours is due to the destructive ionisation of cells in the tissues caused by its gamma-rays. It is therefore obvious that it should also be possible to utilize the gamma radiation of radiocobalt for therapeutic purposes. Already it has been found to have advantages in comparison to radium. Its gamma rays are homogeneous, it is easy to handle and it is cheap. The only disadvantage of radiocobalt in comparison to radium is its relatively short half-life of 5.3 years against the 1,590 years for radium. Radium is thus a source of gamma radiation with constant activity while artificial isotopes are not. This drawback in the case of radiocobalt, however, is outweighed by its advantages.

One convenience of cobalt is that prior to neutron bombardment no risk is incurred in machining it into needles, rods, plates, or other applicators suitable for local use. It also allows a more effective construction of the gamma-cannon than radium does.

[1] Read at the Congress of the Northern Association for Medical Radiology at Aarhus, June 12—14, 1951; submitted for publication, June 12, 1951.

As pointed out above, some mention has already been made in literature on the treatment of uterine cancer with radioactive cobalt. MYERS, MORTON et al., WILSON and others, have published preliminary reports indicating that such treatment has already been introduced. MÜLLER of Zürich has also used radiocobalt in liquid form in a number of cases, applying it in the uterine cavity by means of a rubber balloon. Last year one of us (C.-E. J.) had the opportunity of studying his methods, and this, together with the few published articles on the subject, led us to introduce radiocobalt therapy at the Women's Clinic in Helsingfors. Among the various possible methods, our choice was made in favour of HEYMAN's technique.

Fig. 1. Containers.

The radioactive cobalt, in the form of cylinders 1 cm in length and 4 mm in diameter, was delivered by the Atomic Energy Research Establishment, Harwell, England, at the end of 1950. The therapeutic effect of the amount obtained is the same as that of 600 mg of radium.

Just as in the case of radium it is necessary to eliminate the necrotizing beta-radiation of cobalt. But as the beta particles of this isotope have very low energy, elements of low atomic number may be employed as filters; materials such as aluminium, nickel, rubber and plastics are very suitable and gold and platinum filters are thus not needed.

Our filters were made of nickel with a wall thickness of 0.5 mm, which totally absorbs the beta radiation and about two per cent of the gamma radiation. Nickel 0.1 mm thick would have been sufficient to absorb the beta particles completely, but radiological experience has shown that the chosen thickness is more suitable.

At the present moment, we have a supply of filters for one, two and five pieces of cobalt, corresponding to 30, 60 and 150 mg of radium respectively (Fig. 1); hence different application methods can be used. The small containers are convenient for the so-called »packing method», which consists in filling the uterine cavity with them and placing a longer one in the cervix. Vaginal application is also made very easy as pieces of cobalt may, for instance, be placed in short plastic or rubber

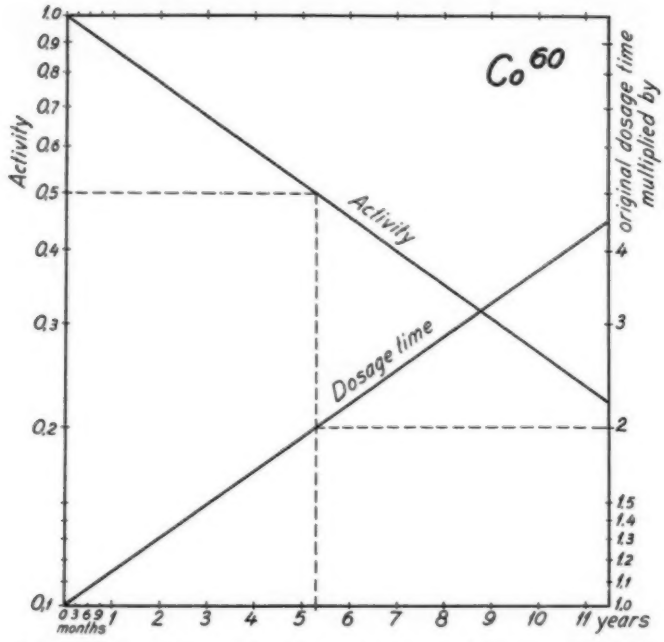


Fig. 2. The activity and dosage time as a function of the time elapsed since the last calibration. The dotted line shows that after 5.3 years (the half-life of $Co^{60}$) the activity (read on the left) is half and the dosage time (read on the right) twice the original.

tubes which are readily adjustable to the anatomical contours (Fig. 1, on the right),

There may, then, seem to be very little difference between the treatment with radioactive cobalt and radium. It may be noted, however, that radium needles are easily damaged and a resulting leakage of radon involves considerable risks. When cobalt is used, this danger is eliminated. It may be noted that sterilization is very easy, the metal not being damaged by heat.

The price of the radioactive cobalt obtained by us was about five per cent of a quantity of radium with the same ionizing effect. In addition, the cost of the filters is negligible, whereas the filters for radium, as known, are expensive.

At a first glance it might seem that the rather rapid decay of the activity in comparison to radium would cause great inconvenience. This is not the case, however, as the half-life is not too short. From the moment

the isotope is calibrated a simple table or graph may be drawn up from which the density of the radiation at any moment can be read (Fig. 2).

The quantity of radium at the Women's Clinic is so small that only one or two patients can be treated simultaneously. The introduction of radiocobalt made it possible to irradiate as many as four patients at the same time. Considering the importance of immediate therapeutic measures in cancer it stands to reason that great hopes may be attached to this new form of therapy.

Many years of experience is of course necessary until a definite evaluation of this method is possible. The results hitherto obtained in our Clinic seem to prove, however, that it is in no respect inferior to radium therapy. A case of cancer of the corpus of the uterus in a 67-year-old woman might be mentioned. In her case the depth of the cavity was reduced within a month from 11.5 to 6.5 cm, haemorrhages ceased, and other favourable effects were noted. To date some thirty patients have been treated. Each of them has been subjected to irradiation two or three times. Owing to the large intensity of the sources, it has been possible to irradiate for shorter periods and this has proved to be of great importance as regards the general condition of the patients. No complications have occurred.

Although it is too early to draw any far-reaching conclusions, our results as well as reports from abroad seem to indicate that radioactive cobalt will play an increasingly important part in the treatment of uterine cancer.

The cheapness of radiocobalt in comparison to radium and the facility in its use is of decisive importance. In view of the great difference in cost, little significance can be attached to the fact that cobalt decays faster than radium. Until the problem of cancer is finally solved, it does not seem wise to spend large sums on radium only because its radioactivity remains constant over many centuries. One may rest assured that radioactive cobalt will provide a better means of combatting cancer of the uterus.

## SUMMARY

The authors point out the advantages of radioactive cobalt as a source of gamma-radiation in the treatment of carcinoma of the uterus. Its ease of application and particularly its price contrast favourably with radium.

## ZUSAMMENFASSUNG

Die Verfasser weisen nachdrücklich auf die ganz besondere Bedeutung des radioaktiven Kobalts als eine Quelle der Gamma-Strahlung bei der Behandlung des Uterus-Carcinoms hin. Die Einfachheit seiner Anwendung und besonders der Anschaffungspreis unterscheiden sich vorteilhaft vom Radium.

## RÉSUMÉ

Les auteurs signalent les avantages du cobalt radioactif comme une source de rayons gamma dans le traitement du cancer de la matrice. La facilité avec laquelle on l'applique, et particulièrement son prix, fait un contraste heureux avec le radium.

## REFERENCES

HEYMAN, J., REUTERWALL, O. and BENNER, S.: The Radiumhemmet Experience with Radiotherapy of the Corpus of the Uterus. Acta Radiol. XXII (1941), 11.

MORTON, J. L., BARNES, A. C., CALLENDINE, Jr., G. W., and MYERS, W. G.: Individualized Interstitial Irradiation of Cancer of the Uterine Cervix Using Cobalt 60 in Needles, Inserted through a Lucite Template. Am. J. Roentgenol. 65 (1951), 737.

MORTON, J. L., CALLENDINE, Jr., G. W. and MYERS, W. G.: Radioactive Cobalt 60 in Plastic Tubing for Interstitial Radiation Therapy. Radiology 56 (1951), 553.

MÜLLER, J. H.: Zur medizinisch-therapeutischen Verwendung der künstlichen Radioaktivität. Bull. schweiz. Akad. d. med. Wissensch. 5 (1949), 484.

MYERS, W. G.: Applications of Artificially Radioactive Isotopes in Therapy. Am. J. Roentgenol. 60 (1948), 816.

WILSON, C. W.: Radiocobalt ($Co^{60}$) as a Therapeutic Alternative to Radium. Am. J. Roentgenol. 65 (1951), 726.

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# MALIGNANT TUMOURS OF THE VULVA[1]

by

*Boye Sten Istre*

In a 10-year series of cases of malignant tumours of the female organs of generation from the Norwegian Radium Hospital (1936—1947), comprising 145 patients, I have found a frequency of vulvar cancer in 7.7 per cent of those treated during the period. All malignant growths of the vulvar region, with the exception of 8 cases of malignant urethral tumors are included in the calculation.

In our material the average age was 63.4 years, the youngest patient being 20 years and the oldest 90 years old (both of them suffering from spinocellular carcinoma), $^2/_3$ of the patients (72.4 per cent) were over 60 years old and $^1/_3$ (33.8 per cent) more than 70 years of age.

It has been noted that the patients, at any rate those primarily treated in the hospital (113 in number), have had signs of leukoplakia in 30 per cent of cases.

Among our cases, as in other series, carcinomas of the labia and clitoris are the dominating types. Cancer of Bartholin's gland, which is classified as a vulvar cancer, is very rare and does not occur in our material.

A very important point in the pathology and treatment of cancer of vulva is its tendency to form metastases and the behaviour of the lymphatics. At operation metastases will usually be found in the lymph glands in from 45 to 60 per cent of the patients. Thus TAUSSIG found metastases in 46 per cent of the operated cases. In our series biopsy gave a positive finding in 21 out of 36 cases where extirpation of the lymphatic glands had been carried out (58.3 per cent). This relatively high figure can be partly explained by the fact, to which I shall later revert, that one of the methods adopted was to refrain from operating until there was clinical evidence of metastases in the lymph glands.

[1] Submitted for publication April 23, 1951.

Meanwhile, it may be difficult to decide from a clinical examination whether metastases in the lymph glands have occurred or not. We must certainly reckon with incorrect diagnoses in the early stages of metastatic deposits in from 20 to 25 per cent of cases. In our material 56 out of 113 patients (49.6 per cent) presented clinical signs of metastases in the inguinal glands at the time of admission to the hospital.

Pathologico-anatomically the vast majority of the malignant tumors in the vulva are squamo-epithelial carcinomas. Such is also the case in this series.

Especially to be noted, however, are 4 basocellular carcinomas, three of which were undoubtedly located in the vulva. In the fourth case the tumor had been removed before admission and it is possible that it was situated in the lower part of the mons pubis and should really have been registered as a tumour of the skin. On account of pronounced kraurosis it was treated primarly by vulvectomy without postoperative irradiation and the patient was free from symptoms for 5 years. In one case the tumour was removed before admission, with subsequent radiation treatment and freedom from symptoms for 12 years. Two patients were primarily treated by radiation. One of them had a local recurrence after $1^1/_2$ years, whereupon electro-coagulation of the tumour was employed; she was free from symptoms for 4 years, when she died of debilitas senilis. This patient had at the same time a basocellular carcinoma of the forehead, which was treated with radium and did not recur. The other patient was free from symptoms for 5 years after primary radiation treatment.

These basocellular carcinomas of the vulva, like basocellular carcinomas in other situations, offer a favourable prognosis and differ distinctly from the actual vulvar carcinomas in their treatment and prognosis. They have therefore not been included in our account of the results attained in treatment of cancer of the vulva.

The same applies to 4 cases of epithelial hyperplasia with atypia. Clinically these cases presented the same appearance as ordinary vulvar tumors and have, broadly speaking, been treated on the same principles. One of these patients afterwards died of general metastases. This case is included in the results, while the other three are omitted.

Five cases of nævocellular tumour-malignant melanoma have all had their primary localisation in the vulva. Clinically they are distinguished by their peculiar type and great malignancy. Likewise these cases are excluded from the material of actual vulvar cancer. — Among 81 malignant melanomas of the skin and vulva from the Radiumhemmet in Stockholm, SCHARNAGEL found 5 cases situated in the vulva (6.2 per cent). All these patients were dead after 5 years, only one of them having lived for more than 3 years. — All our patients died within 3 years.

In one patient with Paget-like changes the tumour was at first situated in the vulva. It recurred several times, with extension to the perineum, anal region and medial sides of the thighs. The patient was treated by irradiation (teleradium and roentgen) and by electro-coagulation of the tumor. She was alive after 11 years. On account of the peculiar form of the disease, this case has also been excluded from the material.

In the one case of malignant lymphoblastoma we have had, an ulcerative tumor embracing the whole of the clitoris region was found. It was treated by vulvectomy and roentgen irradiation. Multiple metastases developed but there was no recurrence in the vulva. The patient died in the course of two years. Another patient with myxofibrosarcoma of the labium majus and operated on in another hospital (excision of tumor), was treated by irriadiation of the vulva and inguinal glands and was free from symptoms after 8 years. These two cases are likewise excluded.

In four cases in which we made no biopsy, or where the biopsy was misleading (adenoid tissue ? granulation tissue ?) all the patients died, the course of the disease rendering the diagnosis of cancer fairly certain. These cases have therefore been included in the account of the results.

### Treatment in Other Clinics

As regards the treatment of cancer vulvae different views are entertained. The following methods have chiefly been adopted:

1. Primary radiological treatment, supplemented, if necessary, by surgical intervention. STOECKEL in 1930 assembled 126 cases treated solely by radiation and found the proportion of cures to be 11.9 per cent. This method is no longer likely to be employed alone.

2. Electro-coagulation of the primary tumour of the vulva with radiological, surgical or combined treatment of regional lymph glands. From the Radiumhemmet in Stockholm BERVEN in 1947 submitted the results attained in 286 cases of vulvar cancer treated by electro-coagulation of the primary tumour with use of a special technique; this was combined with teleradium treatment of the lymph gland regions and secondary toilet of the inguinal glands in certain cases. Of his 384 patients 286, *i. e.* 75 per cent, could be treated in this manner. Of the total material of 384 patients 26 per cent were alive and free from symptoms after 5 years. Of 286 patients treated 38.1 per cent were living and symptom-free after 5 years. The total post-operative mortality rate for the treated patients was 7.6 per cent.

3. Primary surgical treatment (vulvectomy with dissection of the groins), sometimes combined with postoperative irradiation. TAUSSIG in 1940 submitted a statistical account of his results from the Bernhard Free Skin & Cancer Hospital at St. Louis. In a material comprising 155

cases, 117 (75.5 per cent) were subjected to surgical treatment, with or without dissection of the groins. Of 101 cases kept under observation for 5 years or more 32 per cent were free from symptoms. Of the greatest interest, however, are his results in the cases where he adopted radical surgical treatment without postoperative irradiation. In a series of 41 cases 58.5 per cent were free from symptoms for 5 years. It may be mentioned that he reported freedom from symptoms in 10 of 19 cases in which metastases to the lymph glands were noted and in 14 out of 22 where no such metastases were found. His primary mortality was 8.5 per cent.

We have not found in the literature full details as to the results of surgical treatment combined with postoperative irradiation. It may be mentioned, however, that the Mayo Clinic in 1931 had 15.2 per cent cures among 79 cases and FOLSOME in 1940 had 18.5 per cent cures out of 27 patients, while WATSON & GUSBERG had 40 per cent among 26 patients.

### Author's Own Material

At the *Norwegian Radium Hospital* (NRH) two chief methods have been employed: In the General Department the electro-coagulation method (usually with simultaneous excision of the tumour) together with postoperative — in a few cases preoperative — radiation treatment, sometimes supplemented by subsequent toilet of the inguinal glands (BULL ENGELSTAD). In the Gynecological Department, purely surgical treatment (primarily vulvectomy with dissection of the groins, occasionally vulvectomy alone), but with postoperative irradiation in practically all cases.

**Table 1**

| *Treatment* | Pts. |
|---|---|
| Electro-coagulation (+ irradiation) | 53 |
| Ordinary surgery (+ irradiation) | 31 |
| Irradiation | 1 |
| Primarily treated outside the NRH | 26 |
| Intractable | 19 |
| Special patho-anatom. types | 15 |
| Total | 145 |

The Norwegian Radium Hospital's material of malignant tumours of the vulva observed in the 10-year period 1936—1945 comprises 145 patients (Table 1). As earlier mentioned, in 15 cases the histological diagnosis was of a special nature. Of the remaining 130 patients, 25 were primarily treated outside the hospital. Of the intractable group, comprising 19 patients, some received surgical or radiological palliative treatment. Of the 84 patients subjected to operation, 53 were treated by electro-coagulation methods and 31 by ordinary surgical methods ac-

cording to the principles previously mentioned. The degree of operability was 70.6 per cent of the whole material (exclusive of the group »primarily treated outside the NRH»). Radiation treatment alone was only exceptionally adopted, namely, for basocellular carcinomas and in an early case of carcinoma spinocellulare.

An important matter in the judgement of the results of cancer therapy is the classification of the tumour and of its metastases. BERVEN has divided the cases of cancer vulvae into four groups according to the situation, aspect, size and extension of the tumour. Moreover, he has recognized three stages in the metastatic involvement of lymph glands. TAUSSIG has made a classification into five groups according to the character of the tumour and the degree of metastatic spread.

BERVEN's classification has been adopted in our series.

**Table 2**

*Distribution in Groups*

| | Gr. I | Gr. II | Gr. III | Gr. IV |
|---|---|---|---|---|
| Number of patients | 10 | 23 | 41 | 30 |
| Percentages | 9.6 % | 22.1 % | 39.4 % | 28.8 % |

**Table 3**

*Distribution in Stages*

| | St. I | St. II | St. III |
|---|---|---|---|
| Number of patients | 56 | 29 | 19 |
| Percentages | 53.8 % | 27.9 % | 18.3 % |

The distribution of cases, grouped in the above manner, among the 104 patients primarily observed in the NRH, is shown in Tables 2 and 3. As appears from these tables Gr. I and Gr. II together are met with in only about a third of the cases (31.7 per cent), a circumstance which largely influences the results. Half of the patients (53.8 per cent) are apparently in Stage I.

## Results

In our material, which comprises only the actual carcinomas of the vulva (squamous carcinomas) 130 patients have been under observation for 5 years or more, with 5 years' freedom from symptoms in 24.6 per cent of cases.

Of 84 patients primarily treated in the NRH by operation, two died following it (2.4 per cent), one, 71 years of age died of embolism after electro-coagulation, and one, 84 years of age, died of circulatory insufficiency after secondary dissection of the groin.

The distribution into groups and stages for the treated cases, arranged according to the method of treatment, is shown in Table 4.

**Table 4**

*Distribution in groups and stages for the treated cases*

| | Group | | | | Stage | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III |
| Electro-coagulation | | | | | | | |
| Died | 2 | 9 | 14 | 12 | 23 | 8 | 6 |
| Recurr. | 1 | 1 | 3 | | 2 | 3 | |
| Symptom-free | 2 | 4 | 5 | | 9 | 2 | |
| | 5 | 14 | 22 | 12 | | | |
| Surgery | | | | | | | |
| Died | 1 | 6 | 7 | 3 | 6 | 8 | 3 |
| Recurr. | | 2 | 1 | | 2 | 1 | |
| Symptom-free | 3 | 3 | 4 | 1 | 8 | 2 | 1 |
| | 4 | 11 | 12 | 4 | | | |

As is seen, the distribution in the two differently treated groups is different, with a great preponderance of »bad cases» in the electro-coagulation group, and the number is small.

Meanwhile I have assembled the treated patients in Table 5, which shows an average of 5 years' freedom from symptoms in 26.2 per cent of cases. Of 53 patients treated by the coagulation method 11 (20.8 per cent) are living free from symptoms after 5 years. Of 31 patients treated by the surgical method 11 (35.5 per cent) are alive and symptom-free after 5 years.

**Table 5**

*Results* (5 years' observation)

| | Sympt.-f. | Recurr. | Died | Total | Sympt.-free |
|---|---|---|---|---|---|
| Electro-coagulation | 11 | 5 | 37 | 53 | 20.8 % |
| Surgery | 11 | 3 | 17 | 31 | 35.5 % |
| Total | 22 | 8 | 54 | 84 | 26.2 % |

Further observations of »late recurrences» and of recurrences as a whole show that new tumours on a leukoplasic basis are not at all rare.

I must point out that in the entire material there are six patients who are known with certainty to have died of another disease without signs of cancer recurrence. They are included among the patients who died of carcinoma.

## SUMMARY

In a series of cases from the *Norwegian Radium Hospital* comprising 145 malignant tumours of the vulva, the average age of the patients was found to be 63.4 years.

Of the more restricted collection of cases, which included only the actual vulvar carcinomas (squamous carcinomata), 130 patients have been under observation for 5 years or more, with 5 years' freedom from symptoms in 24.6 per cent. Of 53 cases treated by the coagulation method, 11 (20.8 per cent) are living and free from symptoms after

5 years. Of 31 patients treated by the surgical method, 11 (35.5 per cent) are alive and symptomfree after 5 years.

A comparison between the electro-coagulation method and the surgical methods could not be established on account of the dissimilar distribution of cases in the different groups and stages, and owing to the smallness of the figures recorded.

## ZUSAMMENFASSUNG

In einem Material aus dem *Norwegischen Radiumhospital* von 145 malignen Tumoren in der Vulva ergibt sich ein Durchschnittsalter von 63.4 Jahren.

Aus dem engeren Material, in welches nur die eigentlichen Vulvakarzinomen (Plattenepithelkarzinomen) eingehen, wurden 130 Patienten in 5 Jahren oder mehr mit 5-jähriger Symptomfreiheit von 24.6 % beobachtet. Von 53 mit der Elektrokoagulationsmethode behandelten Patienten zeigen 11 (20.8 %) und von 31 mit der chirurgischen Methode behandelten Patienten 11 (35.5 %) eine 5-jährige Symptomfreiheit.

Ein Vergleich zwischen der Elektrokoagulationsmethode und der chirurgischen Methode lässt sich nicht durchführen auf Grund der ungleichen Gruppen- und Stadienverteilung und der kleinen sich ergebenden Zahlen.

## RÉSUMÉ

Dans un matériel provenant de *l'Hôpital Norvégien du Radium* de 145 tumeurs malignes de la vulve, l'âge moyen se trouve être de 63.4 ans.

Du matériel se composant seulement de carcinomes de la vulve (cancers pavimenteux) proprement dits, 130 malades ont été en observation pendant 5 ans ou davantage avec un pourcentage de 24.6 % ne présentant pas de symptômes. Sur 53 malades traités avec la méthode d'électrocoagulation, une moyenne de 20.8 % (11 malades) et sur 31 malades traités avec la méthode chirurgicale, une moyenne de 35.5 % (11 malades) ne présente plus de symptômes après 5 ans.

En raison de la différence de matériel en ce qui concerne la répartition en groupes et en stades de maladie, ainsi que de la modicité des chiffres, il était impossible d'établir une comparaison entre la méthode d'électrocoagulation et la méthode chirurgicale.

## REFERENCES

Berven, E. G. E.: 177 Fälle mit primären Vulvakarzinom. Acta Radiol. XXII (1941), 99.
— Carcinoma of the vulva. Brit. J. Radiol. XXII (1949), 498.
Bull Engelstad, R.: Stråleterapi. Johan Grundt Tanum, Oslo 1946.
Folsome, C. E.: Benign and malignant tumors of the vulva. J. A. M. A. 114 (1940), 1499.
Scharnagel, I. M.: Treatment of malignant melanomas of the skin and vulva at Radiumhemmet, Stockholm, Acta radiol. XIV (1933), 473.
Stoeckel, W.: Lehrbuch der Gynäkologie. Verlag von Hirzel, Leipzig, 1940.
Taussig, F. J.: Late results in the treatment of leucoplakic vulvitis and cancer of the vulva. Am. J. Obst. and Gynec. 31 (1936), 746.
— A study of the lymph glands in cancer of the cervix and cancer of the vulva. Am. J. Obst. and Gynec. 36 (1938), 819.
— Cancer of vulva. An analysis of 155 cases (1911—40). Am. J. Obst. and Gynec. 40 (1940), 764.
Watson, P. B. & Gusberg, S. B.: Prevention and treatment of carcinoma of the vulva. Am. J. Obst. and Gynec. 52 (1946), 179.

FROM THE ROENTGEN DEPARTMENT (DIRECTOR: S. RIBBING), KARLSKOGA HOSPITAL, KARLSKOGA, SWEDEN

# PHYTOBEZOAR[1]

## Report of a case

by

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Bezoar derives from a Persian word (padzahr) meaning antidote; in ancient times concretions of this type were used as remedies. They occur mostly in animals but occasionally even in man, and then in three forms, viz. trichobezoars, phytobezoars and shellac-bezoars.

The first clinical diagnosis of a bezoar was made by SCHREIBER in 1886 and the first roentgen diagnosis in 1911 by KAUFMAN. Radiologically the bezoar appears as a movable defect seen in the barium meal. Peristalsis may be sluggish or absent in the area where the bezoar lies in contact with the stomach wall.

The clinical symptoms vary. Pain, nausea and vomiting may be present. In some cases the pain is relieved by food; this is supposed to be caused by food lodging between the bezoar and the gastric wall and protecting the latter. In certain cases an epigastric tumour is felt on palpation.

Complications of various types have been recorded. Gastritis, ulceration, perforation, haemorrhage and ileus have been observed.

Shellac-bezoars seem to be the rarest. In 1940 INLOW found 10 cases in the German and Norwegian literature, to which he added a case of his own. This type of bezoar exclusively affects men, principally alcoholics who drink solutions of shellac in spirit as intoxicants. The alcohol is absorbed by the gastric mucosa and the shellac remains in the stomach as has been demonstrated experimentally in rats. Ileus and perforations are frequent complications with this type of bezoar.

Trichobezoars and phytobezoars are more common than shellac-bezoars. In 1928 MAES (quoted by LYONS and BODY) had found 139 cases of which 23 were phytobezoars. CHONT in 1942 estimated the num-

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ber of definitely established phytobezoars at roughly 130, most of them from American, but also from English, German, Italian, Hungarian, and Japanese sources. As far as I know, no case of phytobezoar has previously been reported in the Swedish literature.

As a rule phytobezoars originate from persimmon fruits, viz. fruits resembling oranges, *e. g.* those of *Dyospiros virginiana*, *texana*, and *kaki* (»kaki-plums», the Japanese form). The major proportion of the recorded phytobezoars have been observed in the regions of America where these fruits grow, and in Japan. Celery, plums, salsify and pumpkins may also cause phytobezoars but such cases are however very rare. Most of the phytobezoars have been observed in men between 40 and 60 years of age. In French literature attention has been called to the poor dental condition of patients with bezoars. On the other hand, no mention is made in the literature of the dietary habits of the patients. The persimmon fruits contain pectin and gums; according to UPSON (1925) these constituents are kneaded by gastric peristalsis into bezoars. CHONT (1942) succeeded in producing bezoars *in vitro* from unripe persimmon fruits immersed in hydrochloric acid. Experiments with ripe persimmon fruits or other vegetable matter were unsuccessful. In other respects, however, the mechanism of bezoar formation is still obscure.

Trichobezoars, which are composed of hairs, are more common than phytobezoars. A case of this type has been described in Sweden (GRÅBERGER, 1944). The ingestion of hairs is due to various reasons, such as mental abnormality, attempts at suicide, etc. Homicide by the incorporation of hairs in the food has even been attempted. Trichobezoars are globular in shape or may form a cast of the entire gastric cavity; sometimes a tail-like portion may protrude through the pylorus.

*Case report* (Surg. Dept., Karlskoga Hospital, Rec. Nr. 1791/1950). Man, aged 50, with obscure abdominal symptoms, chiefly of enteritic type, in 1943 and 1946. From Jan. 1950 onwards he complained of dull pain, distension in the epigastrium, eructations, and occasional vomiting. Although more comfortable during the spring and summer, he sometimes had pain and heartburn. During the last three years he had gained 10 kg; his weight on admission was 90 kg. Regarding his dietary habits, he was practically a vegetarian. He lived mainly on apples, cabbage, cauliflower, carrots, beetroot and hip-tea.

On examination he was found to be a thick set, fairly obese and muscular subject. His teeth were in poor condition; the upper jaw was edentulous but he had no dental plate. The dental condition of the lower jaw was comparatively satisfactory. The abdomen was large, fat, and lax and was not tender. Palpation was normal. The gastric juice was not examined. Clinical and laboratory examinations gave no evidence of other diseases.

A roentgen examination of the stomach revealed a defect slightly larger than a plum in the barium outline of the canalis. Gastric peristalsis was normal, even in the area corresponding to the defect. The stomach and the duodenal cap were normal in shape and size; the emptying rate was also normal. The roentgen diagnosis was polypus ventriculi. (Fig. 1.)

Fig. 1. Filling defect in canalis suggesting a polypus ventriculi.

At operation (S. MEURLING) the gastric wall was not abnormal upon palpation. A frontal incision was made. There were no pathological changes in the canalis, but examination of the fornix revealed the cause of the defect in the barium meal, viz. a bezoar. In addition, a stone of hazel-nut size was felt on palpation in a pathological gallbladder and cholecystectomy was performed. The bezoar was roughly 4 cm long, was ovoid and plum-shaped. It was comparatively soft and tough in consistence and brownish-black in colour (see Fig. 2). The postoperative course was uneventful and the patient made a recovery to normal health.

Chemical analysis of the bezoar proved difficult on account of its having been immersed, in error, in formalin upon removal; it seemed however to be composed of organic matter (O. WILANDER).

*Microscopic examination* (L. ZETTERGREN). — The concretion removed from the stomach is chiefly composed of vegetable elements varying in size and shape. In addition,

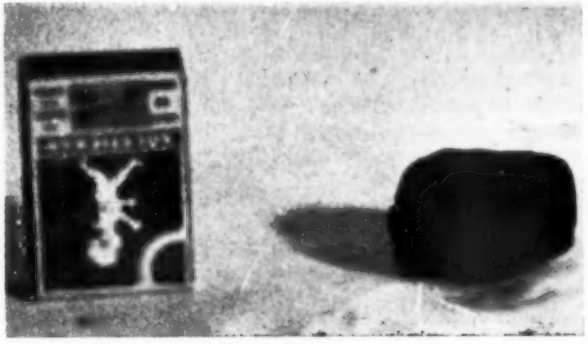

Fig. 2. The bezoar beside a box of matches 5 cm in height.

a few animal fragments are noted. The solid particles are embedded in a hyaline substance which gives a positive mucin test, and which accordingly may reasonably be supposed to represent gastric mucus. The formation may be characterized as a *phytobezoar*.

Fig. 3 shows vegetable fragments embedded in a hyaline substance that gives a positive mucin test.

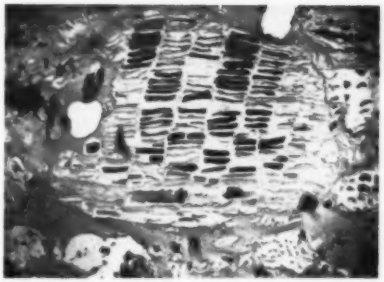

Fig. 3. Vegetable fragments in the bezoar.

Examination of the specimen by a botanist disclosed that it contained numerous fragments of higher plants. There were, *inter alia*, fragments of vessels, partly with spiral and partly with retiform mural structures, as well as cork-like tissue, probably derived from the bark layers of higher plants. Further, a tiny thorn was observed, presumably from the genus *Rosa*. Fungous tissue was absent. The material was not affected by digestive enzymes. Tea prepared from rose-leaves was supposed to be one of the sources of the material (Prof. E. Melin).

Together with the statements made in the literature, the present case seems to suggest that phytobezoars may develop in vegetarians whose teeth are in so poor a condition that the food cannot be properly masticated.

## SUMMARY

A case is reported of a phytobezoar in a male vegetarian aged 50 with poor teeth. The bezoar proved to contain vegetable matter resisting digestion.

## ZUSAMMENFASSUNG

Der Verfasser beschreibt einen Fall von Phytobezoar, der bei einem Vegetarier, einem 50 Jahre alten Mann mit defektem Gebiss, beobachtet wurde. Es erwies sich, dass der Bezoar schwerverdauliche vegetabilische Bestandteile enthielt.

## RÉSUMÉ

L'auteur décrit un cas de phytobézoard chez un homme végétarien de 50 ans qui possédait une denture défectueuse. Le bézoard contenait des particles végétales indigestes.

## REFERENCES

Blondeau, A. et Miramond de la Roquette: Quatre cas de corps étrangers de l'estomac J. de radiol. et d'électrol. 30 (1949), 63.

Burchard, A.: Bezoar in der alten und der modernen Medizin. Fschr. Röntgenstr. 22 (1914—15), 321.

Carr, W. M.: A case of hairball. Radiology 3 (1924), 257.

Chont, L. K.: Phytobezoar and its formation in vitro. Radiology 38 (1942) 14.

Conte, E.: Röntgenologische Betrachtungen über einen Fall von Trichobezoar. Röntgenpraxis 4 (1932), 809.

Gräberger, G.: Über einen Fall von Trichobezoar. Acta radiol. 25 (1944), 504.
Haug, K.: Über einen Fall von Bezoaren. Röntgenpraxis 2 (1930), 520.
Inlow, H.: Shellac-bezoars. Radiology 34 (1940), 618.
Kalbitzer, H.: Über einen Fall von Trichobezoaren. Röntgenpraxis 11 (1939), 414.
Lyons, C. G. and Cody, G. L.: Bezoar. Radiology 31 (1938), 225.
Mc Carley, T. H. and Greenberger, E. D.: Persimmon phytobezoar mistaken for gastric cancer. Radiology 36 (1941), 232.
Pillmore, G. U.: Clinical Radiology: page 540. F. A. Davis Company, Philadelphia 1947.
Porter, W. B. and Mc Kinney, I. T.: Phytobezoar diospyri virginianae. Radiology 8 (1927), 529.
Potter, R. P.: Phytobezoar. Radiology 15 (1930), 685.
Rodgers, F. D.: Phytobezoar of persimmon origin. Radiology 29 (1937), 494.
Rovsing, C. M.: Trichobezoars in the stomach and their demonstration by roentgen examination. Acta radiol. 2 (1923), 491.
Schinz, H. R., Baensch, W., Friedl, E.: Lehrbuch der Röntgendiagnostik, page 1305. Georg Thieme, Leipzig 1932. 3. edit.
Upson, W. O.: Roentgenologic findings in a case of phytobezoar. Radiology 4 (1925), 19.

FROM THE ROENTGEN DEPARTMENT (DIRECTOR: I. SALLINEN) OF THE MARIA HOSPITAL, HELSINKI, FINLAND

# CALCIFICATION OF THE GALLBLADDER WALL[1]

## Report of a case of so-called »porcelain gallbladder»

by

*Kaleri Kettunen*

Calcification of the gallbladder wall is an occasional finding in older patients particularly at autopsy. It represents an end stage of a process of disease which greatly alters the morphology of the gallbladder and completely destroys its function. A small percentage of cases with cholecystitis of long duration and single stone formation may have calfication involving the bladder wall. In cases of long duration malignancy should be considered as a sequel to the irritation caused by the degenerated tissues, particularly in the parts contiguous to the calcified masses. Specifically diagnostic clinical signs of calcification do not exist. Roentgen delineation of the calcifying process is the most satisfactory means available.

The infrequent occurrence of calcification in the gallbladder wall is confirmed by the literature and communications received from authors who have reported studies of a series of gallbladders examined by roentgen and surgical means. Calcification has been reported by BLATTER (1) and others (2—11). The purpose of this paper is to add one additional case to the literature on this unusual condition.

### Case Report

A woman (L. T. 845/51), aged sixty-four years, was admitted to the Maria Hospital in February, 1951, with a tentative diagnosis of tumor of the right kidney. A mass in the right side of the upper abdomen was first noticed thirty years previously. It was diagnosed as ren mobile. The patient gave no typical history of gallbladder disturbance and had never been severely ill. Six months before admission she stumbled on the stairs and felt a dull pain in the right upper quadrant for some time afterwards. In recent months she had had a sense of fullness in the right epigastrium.

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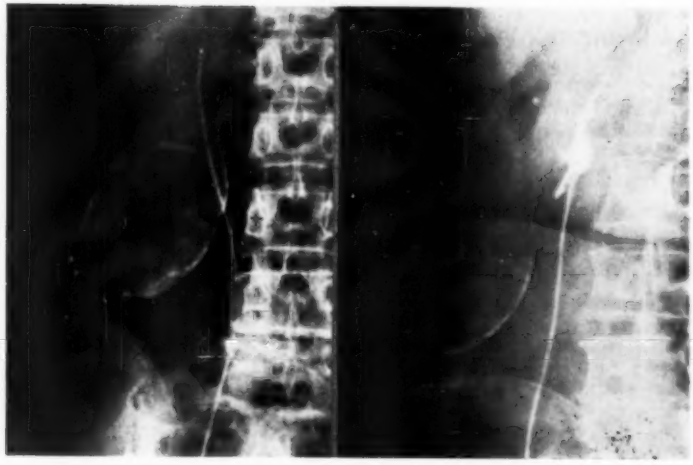

Fig. 1. Fig. 2.

Fig. 1. Shadow with calcareous periphery observed in the gallbladder region during pyelographic examination.

Fig. 2. Oblique view shows the calcareous shadow to be in the anterior part of the abdomen.

Fig. 3. Fig. 4.

Fig. 3. Surgical specimen of calcified gallbladder.

Fig. 4. Photomicrograph (× 600) after staining with von Kossa's stain shows granular deposits of calcium in the fibrous wall.

Physical examination revealed an elderly well-nourished woman not appearing ill. The essential physical findings were confined to the abdomen: some tenderness in the right upper quadrant and a firm palpable mass below the right costal margin. The other findings on physical examination were of little significance except for a slight degree of hypertension (blood pressure 190/110). Blood counts showed hemoglobin 75 per cent; red blood cells, 4,790,000; white cells, 5,700; non-protein nitrogen 20 mg. per 100 c. c.; Kahn test negative. Urine findings were within normal limits.

Retrograde pyelography was negative, but a rigid and fixed shadow with a calcareous periphery was observed, corresponding to the gallbladder in shape and position (Figures 1 and 2). The roentgen diagnosis was »calcified gallbladder».

An operation revealed a large distended, thick, yellowish-white gallbladder with many pericholecystic adhesions. Its wall was thick and granular and could be cut only with the greatest difficulty. The lumen was filled with a mucinous material but free from stones. The cystic duct was found to be completely blocked. Cholecystectomy was performed. The patient made an uneventful recovery and was discharged from the hospital on the tenth post-operative day.

The removed gallbladder, which retained its rigid shape, measured 8.0 × 5.5 × × 5.5 cm. (Fig. 3.) Its wall including the fundus and body extending to the duct was thickened to as much as 4 mm. The serosal surface was pale and the adherent subjacent wall was calcified with areas of calcification also extending into the muscularis. Microscopic examination showed fibrous connective tissue with granular deposits of calcium (Fig. 4). The diagnosis was calcified gallbladder.

## Discussion

A multiple number of causes have been assigned for the calcification of the gallbladder wall. It has been generally noted that gallstones are nearly always present when calcification of the gallbladder occurs, and obstruction of the cystic duct has been reported in a number of cases, but no particular attention seems to have been paid to the relationship between the obstruction and the calcification. A review of articles on calcification of the gallbladder by Robb (8), Talbot (9) and Fowler (5) brings out the fact that the cystic duct was obstructed either by a stone or by scar tissue growing over its orifice in nearly all the reported cases, although no special attention was called to the correlation between the obstruction and the calcification. Phemister, Rewbridge, and Rudisill (7) report several cases to support their opinion that the occurrence of calcium carbonate stones or milky suspension of calcium carbonate follows the obstruction of the cystic duct by stones, carcinoma, or inflammation, the calcium carbonate being produced by the gallbladder wall.

The case reported here was not accompanied by gallstones. Further, there was no history pointing to the previous existence of acute cholecystitis. These facts favour the view that the calcification resulted from a mild and chronic infection obstructing the cystic duct, with a consequent mucocele and distention followed by impaired function and atrophy of the muscular layer with fibrous replacement.

## SUMMARY

A case of calcified gallbladder is reported. The diagnosis was based initially on the characteristic roentgenographic appearance of the gallbladder. The surgical findings and pathological examination confirmed the roentgenographic diagnosis.

## ZUSAMMENFASSUNG

Es wird über einen Fall von Verkalkung der Gallenblase berichtet. Die Diagnose war von vornherein durch die charakteristische röntgenologische Darstellung der Gallenblase gesichert. Der Operationsbefund und das Ergebnis der pathologischen Untersuchung bestätigten die röntgenologische Diagnose.

## RÉSUMÉ

Note sur un cas de vésicule biliaire calcifiée. Le diagnostic avait été établi sur l'apparence caractéristique de l'image radiologique de la vésicule. Les données chirurgicales et anatomo-pathologiques confirmèrent le diagnostic radiologique.

## REFERENCES

1. Blatter, R.: Die Porzellangallenblase im Röntgenbild. Bericht über zwei Fälle. Acta radiol. 15 (1934), 169.
2. Brown, R.: Calcification of the Gallbladder. West. J. Surg. 40 (1932), 70.
3. Davis, J. E., and Bookmyer, R. H.: Intramural Calcification of the Gallbladder. Ann. Surg. 96 (1932), 413.
4. Flörcken, H.: Die »Porzellangallenblase» (Cholecystopathia chronica calcarea). Deutsche Ztschr. f. Chir. 216 (1929), 264.
5. Fowler, W. F.: Calcareous Changes of the Gallbladder Wall. Ann. Surg. 78 (1923), 623.
6. Kopári, J.: Fall einer durch Röntgenuntersuchung diagnostizierten »Kalkgalle». Zentralbl. f. Chir. 67 (1940), 1383.
7. Phemister, D. B., Rewbridge, A. G., and H. Rudisill Jr.: Calcium Carbonate Gallstones and Calcification of the Gallbladder Following Cystic-Duct Obstruction. Ann. Surg. 94 (1931), 493.
8. Robb, J. J.: Observations on Calcification of the Gallbladder: with Presentation of a Case. Brit. J. Surg. 16 (1928), 114.
9. Talbot, P.: Cholelithiasis: Notes on a case with a Calcified Gallbladder. Brit. J. Surg. 8 (1921), 533.
10. Westerkamp, H.: Zur Differentialdiagnose der »Porzellangallenblase». Röntgenpraxis 7 (1935), 751.
11. Zawadowski, W., and Plewniak, W.: Gallenblasenkrebs mit Kalkablagerungen und Porzellangallenblase im Röntgenbild. Röntgenpraxis 8 (1936), 318.